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Summary *of* Apprenticeship Practices

in Foundries

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The National Founders' Association

29 South La Salle Street Chicago, Illinois

The aim of this publication is to give a brief resume of practices and methods now in use in certain foundries. It will be understood that this study is not at all complete. A complete study would require many months and would include many times the amount of material assembled here. This publication, including its appendixes on text material and references, is considered as an emergency announcement of present average practices and methods. It may serve as a tentative guide to those who feel the need for immediate organization of some kind of foundry training. It is published in response to numerous requests from company members for information. An attempt has been made to answer inquiries by giving examples of what is being done to train foundry labor throughout the country.

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NATIONAL FOUNDERS ASSOCIATION
29 South LaSalle Street, Chicago

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A brief summary
of
APPRENTICESHIP PRACTICES

By L. A. Hartley, Director of Education

This is the second of a series of publications dealing with the subject of training foundry apprentices.

Points discussed — Page

1. Introduction,..... 2
2. Apprentice training defined,..... 2
3. Apprentice training distinguished from general upgrading,..... 3
4. Example of apprenticeship growing out of upgrading,..... 4
5. Scope and aim of apprentice training,..... 5
6. Length of apprenticeship,..... 6
7. Rates of pay for apprentices,..... 7
8. Schedules of advancement,..... 10
9. Opportunities for trade finding,..... 15
10. Branches of foundry training,..... 15
11. Shop training - helpful instructional material,..... 16
12. Related instruction - time devoted to it,..... 18
13. Related instruction - where given,..... 18
(1)Cooperative District Plan including public vocational school,..... 19
(2)Cooperative District Plan with privately managed school,... 20
(3)Individual Plant Plan,..... 21
14. Related instruction - instructors,..... 21
15. Related instruction - subjects taught,..... 22
16. Related instruction - some questionable text material,..... 25
17. Related instruction - kinds and examples of text material,.... 26
18. Related instruction - methods of furnishing text material,.... 31
19. What has become of apprentice graduates?..... 32
20. Plan of publications,..... 33
21. Questions for discussion,..... 34

Chart I. Cooperative District Plan including public vocational school,..... 43
Chart II. Cooperative District Plan with privately managed school,..... 44
Chart III. Individual Plant Plan for employe training,..... 45

Appendix I. Making dry sand cores(An example of text material)(Attached)
Appendix II. List of references and texts for the foundry (ed
(Separate copies of Appendixes I and II will be sent upon request)

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1 - Introduction.

When training is mentioned, every one thinks of the kind of activity which to him means training. Apprentice training means as many different things to different people as the varied experiences these people have had which they have called by the name of apprentice training. Every human being naturally thinks in terms of his own experiences.

VARIOUS METHODS AND DEFINITIONS

A brief questionnaire was sent out in May 1924 by Commissioner McClintock of the National Founders Association to determine the extent of the training of molder apprentices which was being carried on by the membership of this Association. A number of companies answered - "No, we are not doing any apprentice training, we are only - - -" and then they went on to describe exactly the same procedure that was described by other companies who began their answers with - "Yes, we are training apprentices by, etc. - - -". It was evident that some foundrymen considered they were training apprentices when they were doing exactly the same thing as other foundrymen were doing who believed they were not really training workers by the apprenticeship method.

MEETING AN EMERGENCY

It is agreed rather generally that an emergency exists regarding the production of skill in foundry labor and that widespread active cooperation is needed in order to meet this emergency. Farsighted men realize that they must at first train enough workers to allow for losing a few to those plants who are not yet ready to cooperate on this point of producing skill.

In order to cooperate we must understand each other - must mean the same thing when we use the same terms. Unanimous action depends upon common understanding.

APPRENTICE-SHIP AND UPGRADING

Apprenticeship and apprentice training are confused with upgrading of personnel by many foundrymen. The following distinctions and definitions are not arbitrary. They are developed from expressions commonly heard thruout the foundry industry and are in accordance with the recommendations of the Industrial Education Committee of the National Founders Association.

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2 - Apprentice training defined.

The following definition is suggested as expressing the concensus of opinion of those practical people who have had wide experience in this field:

> Apprentice training is any systematic training in the all-round practice of any given trade including regular advancement in shop operations together with regular instruction in those subjects which will make the performance of these trade operations, easier, cheaper and more interesting.

HOW TO HAVE A WAITING LIST OF YOUNG MEN

The general acceptance of this definition will do much to guide the training program by means of which the better type of American youth will be brought into the foundries of this country and will be trained to supply the skill needed by this industry. This apparently bold statement is based upon the fact that in a number of industrial centers in which this kind of apprentice training has been in operation for some time there are waiting lists of desirable young Americans who wish to avail themselves of this opportunity for education.

IT CAN BE DONE

A quotation may be of interest from a company which began single handed to train apprentices a few years ago with no cooperation from the public schools or other plants. Before giving the quotation it should be stated that this company is hoping to have the cooperation of the public schools as well as that of other concerns. In March 1925 an official of this company wrote:

THE BEST KIND OF YOUNG MEN

"Five years ago we had absolutely no applications for the foundry trades. Today we have on file forty-one applications, none over three or four months old from whom we can probably select at least ten good boys as openings occur. - - - We carried our apprentices all thru the depression and did not have them on laboring jobs either, although they had a few weeks of short time, some of them alternating week about for a while."

This firm prefers boys of American rather than those of foreign parentage because "they can be relied upon to stick".

3 - Apprentice training distinguished from general upgrading.

This definition of apprentice training will make clear the distinction between an apprenticeship program and a system of upgrading promising workers.

UPGRADING FROM THE GANGWAY ALWAYS PAYS

The general upgrading of foundry labor is done in a more or less effective manner thruout the industry. It will always pay to give special attention to workers showing special interest and ability and to promote them from job to job as they gain skill. Many capable workers and foremen have been developed by this process. This plan of upgrading differs from apprentice training in three important essentials:

AIMS DIFFER

(1) Aim - The aim of apprentice training is to produce skilled foundrymen with production of castings as a by-product of training. The upgrading system of training aims to produce castings with training of foundry workers as a by-product of foundry operations.

INSTRUCTION GIVEN TO APPRENTICES

(2) Related instruction - There usually is very little if any related instruction in connection with upgrading foundry labor. Apprentice training includes the related instruction which is needed by the worker in order to understand trade operations and his place in the industrial system.

SUCCESSFUL TRAINING IS SYSTEMATIZED

(3) Responsibility assumed - In apprentice training, the industry definitely assumes the responsibility for attracting the desirable type of young men into the foundry and for preparing them by systematic training and instruction so that they may give the industry the largest service of which they are capable. This responsibility naturally leads to cooperation between different companies and the development of foundry labor for the industry as a whole. In upgrading, the worker is largely responsible for his own interest in advancement. Naturally he may not be greatly interested in the foundry industry - this is the responsibility of the management. The industrial worker already employed must show his ability and interest before he is given any special training. Usually no one assumes responsibility for systematically planning training by the upgrading process and such training practically never is undertaken for the purpose of developing a plant's share of the skilled labor in the foundry industry as a whole.

4 - Example of apprenticeship growing out of upgrading

The distinction and also the close relation between apprenticeship and upgrading are illustrated by a successful training program in a plant in one of the smaller cities of the middle West. A large factory in Moline, Illinois has a system of training which is functioning admirably although there is no connection with a public school. The work in this factory does not include a variety of experiences; in fact, the operations are largely mechanical and would be considered by some to hold very little training content. The management has not tried to elaborate upon the training possibilities which it offers.

RATING APPRENTICES THRU THE UPGRADING PROCESS

The first step in developing training in this plant was to select a certain number of jobs and to decide upon a fair performance and a fair average wage to be earned each day. This became the qualification for a special apprenticeship. Any one who is able to earn $5.00 a day at the prevailing piece rates, whose work is of a certain standard and who has successfully completed a certain number of jobs, is eligible to become a Grade A apprentice. A performance of approximately twice this quantity, an experience in four times the number of jobs and an earning capacity of $7.00 a day entitles a Grade A apprentice to examination as journeyman.

The management of this company felt an obligation to offer certain related instruction and this necessitated the employment of a person who not only knew mathematics, drawing, science

and other school subjects, but who also knew the shop operations to which certain parts of these subjects relate.

VIEWPOINT ESSENTIAL FOR SUPERVISORS OF TRAINING

A young man who seemed to grasp the problem was found in a university where he was devoting a part of his time to coaching in athletics, but he had had very little industrial experience and none at all in the industry in which he was to be employed. He was put to work in the common gang along with the rest of the untrained help and did all the jobs the others were expected to do. When he could earn $5.00 a day and when his work was of Grade A quality he was advanced. After he had earned the right to be called journeyman he was put in charge of training.

TEACHING WORKERS INSTEAD OF SUBJECTS

This man is not expected to teach related subjects particularly. He is expected to teach young men what they need to know and for that matter, older men if need be for in this plant there is no age limit on apprenticeship or other employe training. Neither is there any specified time required to complete the learning of a trade. Three years is considered fair but there is no limit. This management does not care to have its training system referred to as a finished product. They say they are just getting started. It may be considered a good start.

This training program which has grown out of upgrading and is adapted to the needs of this plant will be found to have the evidences of apprentice training as stated below.

5 - Scope and aim of apprentice training.

An apprenticeship program is composed of two supplementary parts:

THE TWO EVIDENCES OF APPRENTICESHIP

A - Shop training.

B - School instruction related to shop training.

A - Shop training is planned to include experience in all or as nearly all as possible of the jobs in the trade. This usually includes cupola practice. This training aims to produce the all-round workers desired and also to lay the foundation for later supervisory work by those who show capacity for executive responsibility.

In order to provide this broad shop experience the cooperation of a number of foundries is often but not always essential. Such cooperative programs are now functioning excellently in a few places. This is discussed on pages 19 and 20 under the subject, "Cooperative District Plan including a public vocational school" and on pages 19-20-21 under the subject, "Cooperative District Plan with privately managed school."

Whether all the plants in a district are cooperating or an isolated shop is arranging an apprentice program, the essential in both cases is a schedule of advancement by jobs. These schedules are discussed in more detail on pages 10-14.

B - The school or class room instruction of apprentices includes the teaching of subjects which will give an understanding of shop work.

RELATED INSTRUCTION SHOULD PAY DIVIDENDS

The aim of related instruction should always be to render the performance of shop labor easier and cheaper. In all cases in which this aim of related instruction has been carefully considered thruout apprenticeship, this class room instruction has been found to be a paying proposition. Where it is not followed, there is a possibility that the time spent in the class room will be doubly wasted.

INSTRUCTION HAS BEEN MADE TO PAY

Following this aim not only makes class room instruction pay in dollars and cents but it also results in attracting into the foundry the better type of American youth. These are well established facts in centers in which apprenticeship has been in operation for a number of years with thousands of young men. It is interesting to note how much alike human nature and industrial operations are everywhere: A company which began in February 1925 to give six hours a week of class instruction to six of its nine apprentices, wrote March 23, 1925, "We find that the best of our apprentices desire class instruction and it does stimulate an interest in their work. We see marked improvement in the class of work turned out".

The subjects which may be taught to apprentices in order to increase their understanding of shop work and their interest in it are discussed on pages 22, 23, 24 and 25.

6 - Length of apprenticeship

The length of an apprenticeship course differs in different plants and also in the same plant according to the student's previous preparation and to his speed of advancement which in some cases is made dependent upon the boy's interest and ability.

FOUR, THREE AND TWO YEAR COURSES

Four years is the longest course. This is usually found where the foundry operations are varied or where several foundries cooperate to furnish varied experience. This time is sometimes shortened to three years for High School graduates or for students who exhibit unusual proficiency in the work. A two year course for University graduates is also provided in the Milwaukee district and a few other places.

The shorter courses are usually found where the foundry operations are not sufficiently varied to furnish an all-round experience in foundry practices. They are arranged also, as stated above, for students who are able to complete their training in less than the average time.

WHERE TIME IS REDUCED BY GOOD WORK

A plant in Pittsburgh whose schedule of rates for foundry apprentices is given later, encourages both shop work and study by allowing credit for excellence in foundry practice combined with excellence in class work. Every apprentice is graded at the end of each term as A, B or C. Grade A apprentices may complete the next term in 75% of the maximum hours required, Grade B apprentices are required to complete 87½% of the maximum and Grade C 100% - that is, a Grade A apprentice learns his trade and advances in wages in three-fourths of the time required for a Grade C apprentice while a Grade B boy advances in seven-eighths of the time.

PERIODS OF TRAINING

Whatever the length of the term of apprenticeship in years this term is in most cases divided into definite periods which mark the advancement of the apprentice. After each term the pay of the apprentice is increased.

7 - Rates of pay for apprentices.

The rates of pay for apprentices, as would be expected, differ in different localities and in the same plant for different classes of apprentices. For this reason, in addition to several schedules of rates, consideration is given in this publication to the basis upon which these schedules are formed. Basing the pay of apprentices upon essential factors may lead to different schedules in various localities.

FOUR RATES IN ONE PLANT

One firm in Milwaukee has four schedules of rates for apprentices: (1) The four year regular apprenticeship in which an eighth grade education is required for entrance, (2) three year apprenticeship for high school graduates, (3) three year apprenticeship for adult specials and (4) two year apprenticeship for university graduates.

These rates are as follows:

	Grade school graduates 4 year course	High school graduates 3 year course	Specials 3 year course	College graduates 2 year course
1st period	22½¢	35¢	40¢	45¢
2nd "	27½¢	37¢	42½¢	50¢
3rd "	29¢	39¢	45¢	52½¢
4th "	30¢	40¢	50¢	55¢
5th "	32½¢	42¢	52½¢	
6th "	35¢	45¢	55¢	
7th "	37½¢			
8th "	44¢			
A BONUS IS SOMETIMES PAID UPON COMPLETION OF CONTRACT	$100.00	75.00	---	---

Another company in Milwaukee does not give a bonus and pays the following rates:

	4 year course for regular apprentices	2 year course for college graduates
1st period	32¢	45¢
2nd "	33¢	50¢
3rd "	34¢	52½¢
4th "	35¢	55¢
5th "	36¢	
6th "	38¢	
7th "	40¢	
8th "	42¢	

It is understood that these wage scales may be altered either upward or downward to maintain a reasonable ratio between apprentice and journeymen wages.

A plant in Pittsburgh, Pa. has the following schedule of rates for foundry apprentices:

1st	six	months	25¢
2nd	"	"	30¢
3rd	"	"	35¢
4th	"	"	40¢
5th	"	"	45¢
6th	"	"	50¢
7th	"	"	55¢
8th	"	"	60¢

A BONUS BASED ON GOOD WORK

A company with more than a half century's experience in training apprentices pays, in addition to the regular rates, an hourly bonus to those boys who receive "Ex" (meaning excellent) rating in both shop and school.

The Industrial Association of San Francisco in a report dated September 1924, recommends the following rates of pay:

DAY RATES FOR APPRENTICES

"Apprentices should be carefully selected and started at $3.50 per day, put on probation under observation for one month and if after that time, they demonstrate the necessary qualifications for learning the trade, they should be advanced to $3.75. After two months of training, they should be advanced to $4.00. If they are in good standing in the work done in the shop and in their training classes, the following schedule is recommended:

Advanced to	$4.50	after		8 mos.,	if	in	good	standing
"	5.00	"	1 yr.		"	"	"	"
"	5.50	"	1 yr.	4 mos.	"	"	"	"
"	6.00	"	1 yr.	8 mos.	"	"	"	"
"	6.50	"	2 yrs.		"	"	"	"
"	7.00	"	2 yrs.	4 mos.	"	"	"	"
	7.50							
to	8.00	"	3 yrs.		"	"	"	"

(and can qualify as an all-round mechanic)"

A YEARLY BONUS

In addition to this daily rate a bonus of $75.00 to $100,00 is recommended, "one-third to be paid when the apprentice has successfully passed the qualifications for $5.00 rating which would ordinarily be at the end of one year of training, one-third when he has successfully passed the qualifications for $6.50 rating which would be at the end of the second year, and the balance at the end of the third year when he has qualified for journeyman rating".

BOOKS AS GIFTS TO APPRENTICES

This committee recommends also that at various stages apprentices should be presented with copies of books that will be helpful and that after the first year they should receive a subscription to "The Foundry".

APPRENTICE RATES BASED UPON PERCENTAGE OF JOURNEYMAN WAGES

The usual practice with reference to establishing rates of pay for apprentices is to determine a beginning rate which is a certain percentage of the prevailing hourly rate for highly skilled molders or coremakers as the case may be.

Some plants carrying on very successful foundry training offer apprentices opportunity to share in bonuses and piece price schedules. There seems to be a consensus of opinion, however, that the first part of the apprentice's experience should be upon an hourly or day basis. This is probably because of the necessity for subordinating production to instruction. In other words, the apprentice should be encouraged to take enough time to make sure that he is familiar with the various operations and that he thoroughly understands what is to be done, how it is performed and why each operation is performed in any particular manner.

The United States Training Service in Training Bulletin No. 24, "Industrial Training for Foundry Workers", 1919, on page 29, submits as a suggestion the following tentative compensation rate:

	Per cent of journeymen's pay suggested for apprentices
1st period,	33%
2nd "	36%
3rd "	39%
4th "	43%
5th "	47%
6th "	52%
7th "	58%
8th "	66%

Approximate hours (spent in each wage period).

	Each period	Entire course
Grade A apprentice,	825	6,600
Grade B apprentice,	962	7,700
Grade C apprentice,	1,100	8,800

GRADING APPRENTICES BY YEARS REQUIRED FOR TRAINING

On Page 24 of this bulletin it is stated that Grade A apprentices are those who can complete their training in 3 years, Grade B, those who require 3½ years and Grade C, those who require 4 years to complete their apprenticeship.

Many people have come to believe that the exact rate of pay of apprentices is not as important a factor in attracting and holding apprentices as is their systematic training and promotion from job to job.

A company which has had seventy years' experience with apprentice training pays $100. bonus but requires each apprentice to pay $25.00 for his training at the time he is accepted. This company reports however, that it is almost impossible to secure apprentices for the foundry.

The following quotation is taken from a paper presented to the 1923 convention of the American Foundrymen's Association, Pages 493-4, Vol. XXI, Transactions of the American Foundrymen's Association:

ALL-ROUND TRAINING MORE IMPORTANT THAN RATES OF PAY

"Any number of young men can be persuaded to enter an apprenticeship with high wages as a bait but not until they have spent several months in it do they realize that genuine interest in them on the part of the employer is much more valuable than so much per hour. When it becomes necessary for an apprentice to ask repeatedly for a class of work to which he is entitled but does not receive, or when he sees that he is treated as a helper, or as a necessary nuisance around the shop, he quits in discouragement and leaves the trade entirely or goes to another employer who he knows will give him proper recognition. These are not theories but facts that we meet with every day. I say therefore, that the employer who can show his apprentices, who earn only 20 cents per hour, that he is sincere in his desire to give them every chance to learn the whole trade, and not depend entirely on the whims of his foreman, will have a more successful apprenticeship system than the employer who pays his apprentices 60 cents per hour but who expects the learner to pick up the trade while performing helper's or laborer's work."

8 - Schedules of advancement.

A schedule of advancement by jobs is necessary in order to get the "systematic training in the all-round practice of a trade" which is set up in the generally accepted definition of apprenticeship. The advancement of apprentices is usually at regular intervals of time consistent with the ability of the majority of apprentices to learn thoroughly each class of work.

ADVANCEMENT BY JOBS

Somewhat different schedules of advancement are preferred by various companies but usually every apprentice is aware of the approximate time spent on one class of work and the probable route of his progress thru the foundry. The time distributions of the work schedules however, are usually adjusted in accordance with the ability of the apprentice and the state of work in the foundry. A few of the schedules of advancement in different plants are given here. The Education Department is making a collection of these schedules of advancement and is particularly glad to receive those that have proved unusually successful in producing interested skilled workers.

One Milwaukee plant has the following general schedule for both iron and brass molders in a four year apprenticeship:

Core room,	3 to 6 months
Molder helper,	6 " 9 "
Machine molder,	6 " 9 "
Ordinary flask work,	12 " 16 "
Heavy work, loam and dry sand,	6 " 12 "

Another Milwaukee plant has the following schedule of foundry advancement in its four year apprenticeship:

ADVANCEMENT BY HOURS IN FOUNDRY DIVISIONS

Helping molding,	400 hours
Machine molding,	400 "
Bench molding,	650 "
Large cores,	700 "
Small cores,	650 "
Miscellaneous floor work,	650 "
Heat treating,	600 "
Furnace,	600 "
Green sand molding,	1200 "
Dry sand molding,	1200 "
Sweep molding,	850 "
Casting - checking - sand mixing - sifting - crane work - time study - night work, etc.,	1110 "
Chipping room,	750 "
Total	9760 "

This firm has the following schedule of work for three year apprentices who are graduates of high schools:

Helping molding,	300 hours
Machine molding,	300 "
Bench molding,	600 "
Large cores,	600 "
Small cores,	600 "
Miscellaneous floor work,	200 "
Heat treating,	600 "
Furnace,	400 "

(Continued on Page 12)

Total from Page 11)	3600	
Green sand molding,.....	1150	hours
Dry sand molding,.....	1000	"
Sweep molding - casting checking - shipping room- chipping room - sand mixing - sand sifting - crane work - laboratory - weighing and loading charges,.....	1570	"
Total	7320	"

This company has also different schedules for the 3 year adult special apprentices and the 2 year university graduate apprentices. The latter is given here to illustrate the type of practical training which added to college training should help to produce executives.

Schedule of work for 2 year university graduate apprentices:

RAPID ADVANCEMENT FOR POTENTIAL EXECUTIVES

Helping molding,.....	200	hours
Bench molding,.....	300	"
Large cores,.....	400	"
Small cores,.....	200	"
Heat treating,.....	600	"
Furnace,.....	600	"
Green sand molding,.....	750	"
Dry sand molding,.....	550	"
Sweep molding - casting - checking - shipping room - chipping room - sand mixing - night work - special work - laboratory - weighing and loading charges,.....	1280	"
Total	4880	"

A firm which lists the different classes of work as required or alternative has the following schedule:

A VARIABLE SCHEDULE OF EXPERIENCE

* Required.

** Alternative.

	Months required
Stock cores, iron) Stock cores, steel) **.....	* 2
Small bench cores, iron) Small bench cores, steel) **.....	* 2
Medium size cores, iron) Medium size cores, steel) **.....	* 2

	Months required
Helping molder on green sand,.....	* 6
Helping molder on dry sand,.....	* 6
Helping molder on loam,.....	6
Pattern repair, helping pattern maker,.....	* 3
Cleaning castings,.....	* 1
Molding, small, I. foundry,.....	6
Molding, medium, I. foundry) Molding, medium, S. foundry) **	*12
Molding, large, I. foundry (helping),.....	
Molding, medium, I. foundry (helping),.....	
Molding, medium, S. foundry (helping),.....	
Molding, gear floor,.....	
Molding, open sand,.....	
General labor,.....	
Sand mixing (helping).....	

The following procedure for the advancement of apprentices is recommended by the Industrial Association of San Francisco as far as it is practicable:

A GENERAL SCHEDULE OF ADVANCEMENT

"1. Preliminary odd jobs in each department in order to become acquainted with the foundry: getting out and returning patterns; getting in flasks; assisting in preparation of sand, etc.; helping flask carpenter. During this time he should receive general instruction and explanation to arouse his interest.

2. Snap flask work -

(a) Squeezer plain plated work - no cores.
(b) Squeezer work - plain plated, with cores.
(c) More difficult, irregular parting. Jolt squeeze machines.
(d) Gated patterns with hard match.
(e) Hand work - loose patterns, or gated patterns without hard match.

3. Light, simple core work.

4. General instruction.

5. Light side floor work, graded.

   (a) Machine.
   (b) Hand work.

6. Heavy floor work - graded.

7. Cupola.

"Work should be so graded by proper assignment and training, that the apprentice will earn his wage at each step."

ROUTING BY DEPARTMENTS

A tentative routing of apprentices and time in each department is suggested in Training Bulletin No. 24, "Industrial Training for Foundry Workers", U. S. Department of Labor, Page 24. It is as follows:

	Approximate per cent of entire course	Approximate hours A	B	C
Helper to side floor molder	3	196	230	264
Helper in core room	3	196	230	264
Cleaning room	3	196	230	264
Core and mixing room and ovens	3	196	230	264
Mixing foundry facings	½	41	44	44
Bench molder	12½	825	964	1100
Core maker	12½	825	964	1100
Assistant to molder	8½	561	650	750
Apprentice molder on floor	29	1914	2240	2550
On furnaces, assistant to melter	7	462	540	616
Molder on floor	12	792	920	1056
Assistant to foreman	6	396	461	528
Total	100	6600	7700	8800

A, B and C above, refer as explained previously to apprentices requiring 3 years, 3½ years and 4 years to complete their apprenticeships. In a note following the above table the authors of the bulletin state that "The above routing is general and of necessity must be flexible so as to meet the requirement of the foundry, ability and progress of the apprentices, etc."

9 - Opportunities for trade finding

Trade finding courses are given in the Milwaukee Continuation School to boys who request enrollment as prospective apprentices. In all such cases boys are placed on probation for a variable period of from 3 to 6 months. During this time the boy is allowed to work in as many different trades as is convenient to school practice and the boy's schedule. In this way a boy may gain a little understanding of machine shop work, forge practice, carpentry, foundry procedure or other trades in which he is interested.

TRADE FINDING COURSES SHOULD BE ENCOURAGED

There is much to recommend these trade finding courses. If properly conducted they become laboratories of vocational guidance which can function admirably for both industry and students.

Chicago, Philadelphia, Boston, Pittsburgh, New York, Detroit, Buffalo, San Francisco, Oakland, Cincinnati and many other cities provide trade finding opportunities for students. In some instances this training has been developed within only limited experiences but these could be elaborated and made quite generally effective.

A company which realizes the importance of workers' understanding more than the jobs they are performing, schedules all machine shop apprentices for one month in the foundry in the early part of their training. This experience is said by some not only to be of value later in the machine shop work but also to lead a number of the machinist apprentices to remain in the foundry.

10 - Branches of foundry training.

Specialization in industry has led to the development of many specialty shops employing specialty molders. These workers can frequently be trained in a very short time but the large numbers of these specialized workers in no way decreases the very real need for producing all-round molders. In this connection the extent of the various branches of the foundry industry may be of interest to those concerned in training all-round molders.

The branches of foundry training mentioned on Pages 14-17 of Training Bulletin No. 24, U. S. Department of Labor, include the following operations under four general divisions:

Gray and chilled iron foundry

- Green sand molding
- Dry sand molding
- Loam molding
- Metal molds
- Green sand core making
- Dry sand core making
- Metal cores
- Cupola melting
- Reverberatory melting

Malleable iron foundry

- Green sand molding
- Dry sand molding
- Metal molds
- Green sand core making
- Dry sand core making
- Metal cores
- Cupola melting
- Reverberatory melting
- Open hearth melting

Gray and chilled iron - cont'd

Hand pouring
Mechanical pouring
Hand cleaning
Mechanical cleaning
Chemical cleaning

Steel foundry

Green sand molding
Dry sand molding
Dry sand core making
Crucible melting
Open hearth melting
Cupola melting
Converter melting
Electric melting
Hand pouring
Mechanical pouring
Hand cleaning
Mechanical cleaning
Chemical cleaning
Heat treating

Malleable iron foundry - cont'd

Electric melting
Hand pouring
Mechanical pouring
Annealing ovens
Hand cleaning
Mechanical cleaning
Chemical cleaning

Non-ferrous foundry

Green sand molding
Dry sand molding
Loam molding
Metal molds
Green sand core making
Dry sand core making
Metal cores
Crucible melting
Reverberatory melting
Electric melting
Hand pouring
Mechanical pouring
Hand cleaning
Mechanical cleaning
Chemical cleaning

11 - Shop training--helpful instructional material.

Satisfactory shop training is carried on in many plants without the use of any written instructional material. There is one kind of instructional material however which is so generally useful that it should be brought to the attention of all executives and its preparation should be greatly extended in industrial plants.

ONE WAY TO INSURE AN INDUSTRY

Brief interesting descriptions of processes and materials as they are encountered by workers in their first acquaintance with certain processes, have proved of value to the foremen in small plants who with limited time are helping apprentices and other new workers to get started right. They are considered essential also in many large shops.

General descriptions of processes encountered in foundries may be very briefly written by foremen in exactly the language in which they would describe the processes to workers on the job. The putting of this material on paper frequently calls to attention many questions as to the exact methods by which jobs are to be performed.

Since details of methods of work differ more or less in different shops, with various foremen and with the particular work in hand, it is evident that new workers should be supplied with information as to how a process is generally carried on together with enough explanation to arouse their interest and to fix

the process in memory. This is one reason for suggesting that foremen be interested in putting this material on paper. If these descriptions are typed or otherwise put in shape for the use of apprentices and other new workers under the direction of a foreman, the foreman will find that the effort spent in writing this material has been a good investment for himself as well as for the workers.

This descriptive material should be supplemented by practical questions which will serve two purposes - first, to test the worker's understanding of his work and second, to encourage him to improve this understanding.

QUESTIONS SHOULD STIMULATE CONSTRUCTIVE THINKING

In order to serve these purposes the questions should be so stated that the person answering them must think and in this thinking must use his factory experience in addition to the information given in the text material. Reasoning questions especially appeal to intelligent journeymen and become the subject of many discussions. An employer said recently that he could tell the subject studied the evening before by the sketches and figures made during the lunch hour. Questions which can be answered by "yes" or "no" - sometimes called "guess questions", and those which can be answered by exactly repeating the text material - so called "memory questions", should be avoided.

Experts have much to contribute to their industries thru the preparation of this descriptive material supplemented by the type of questions which they have frequently been asked by journeymen as well as apprentices.

SHOP SKETCHES OF VALUE

The value of reference material is increased by the addition of cuts of apparatus, tools and other illustrative material. These illustrations fortunately can be reproduced on inexpensive mimeographed pages as well as in printed matter.

This instructional material should always be in such shape that it can be easily modified as the need is found for changing some detail of the work, giving directions more definitely, adding other illustrations or modifying the questions for study.

Simple reference material is helpful in the rapid training of specialty men and molding machine operators and in various types of work.

Another use of this material is apparent to the manager who is attempting to attract the better type of workers into his foundry by offering them opportunities for study and advancement. The topics contain just barely enough of the reasons to enable a fairly intelligent worker to grasp his work quickly so they may easily be used as a basis for study of the sciences and related drawing which explain reasons for failures and suggest means of improving processes. This interest in the every day "Why's" of foundry practice is shown whenever a trained practical foundryman visits a class of apprentices or students in school who are having difficulty with some foundry job.

An example of a description of a process and the related questions is given in Appendix I of this leaflet which was prepared by Mr. W. C. Wright of the National Founders Association.

The training departments of a number of companies and associations of foundries have prepared very helpful instructional material of the type described above.

A SERVICE PLANNED FOR COMPANY MEMBERS

The Education Department is arranging for the collection and distribution of this material which has already been prepared by foundry officials and associations and in addition has arranged with Mr. Wright to prepare a progressive series of general descriptions of processes similar to the one given in Appendix I.

If there is sufficient interest to warrant the continuance of this series by Mr. Wright the Association is willing to serve its company members with this text material for all those divisions of the foundry in which a need exists for this service. This plan is entirely dependent however upon the interest of company members and the requests of foundry officials for this material.

12 - Related instruction - time devoted to it.

Since industrial managers are striving for the type of related instruction which interests the better class of apprentices and which pays financially, this class room teaching is usually carried on during the regular working hours of apprentices. The apprentices for a certain number of hours per week are sent to a class room either in the plant or in a public or private school building where they are given instruction in subjects a knowledge of which will improve their foundry practice.

TIME IS NOT LOST IF USED TO ADVANTAGE

The time devoted to related instruction is usually four hours a week, although some companies give five hours and even five and one-half hours, on pay time. If it is organized for 144 clock hours a year or for four hours a week during not less than 36 weeks a year it will meet the requirements of the plans of most state and local school boards and may therefore be organized in cooperation with public schools with teachers' salaries paid from public funds. These funds have for several years been available for the practical instruction of workers employed in industry.

13 - Related instruction - where given.

The place in which related instruction is given depends upon the facilities of the plant or plants and the cooperation of schools or other organizations. The selection of the place in which related subjects are taught may influence the choice of instructors and even the lessons taught and is a large factor in the financing, so it is worthy of careful attention. Any one of the three plans for foundry training which are shown in Charts 1, 2 and 3 on pages 43, 44 and 45 may be used in providing class room

space for the use of apprentices. Modification of one of these three plans will be necessary in some places and one plan may be used temporarily while a better one is being developed. A plan can be found which will work now in any plant to the satisfaction of all parties. These three general plans are as follows:

(1)The Cooperative District Plan including a public vocational school, Chart 1, page 43. A modification of this plan is found where one plant alone cooperates with the public school. A small beginning with one plant may lead to the effective district plan serving all the foundries in the district.

NEITHER CLASS ROOMS NOR TEACHERS CAN TAKE THE PLACE OF A WELL ORGANIZED PLAN

(2)The Cooperative District Plan with privately managed school which is a cooperative plant school, Chart 2, page 44. This may later grow into plan (1).

(3)The Individual Plant Plan in which the management of one plant single handed attacks the problem of apprentice training, Chart 3, page 45. This may grow into plans (2) and (1) but it can be made to pay meanwhile. One answer to a recent questionnaire on foundry training said, "We seem to train molders for all the other companies who don't do it themselves but we get enough skilled molders and executives for our own plant, so that we figure it pays anyway".

(1)When the public schools cooperate, class rooms may be set aside for apprentices at times and in buildings where apprentices can attend conveniently and in which the class room surroundings are conducive to discipline. An entire building is given over to this type of instruction in at least one center where all the industries cooperate with the public schools. This is the Cooperative District Plan including a public vocational school and is a goal worthy of striving for.

In some localities in which class rooms in public school buildings have not been found convenient for employed persons and where one or a few isolated plants are cooperating with the public schools, the school officials have recognized one or more plant schools in local shops as "extensions of the public schools." In these cases the public schools also furnish instructors or pay their salaries. This has been done very effectively in Birmingham, Alabama and in Omaha, Nebraska. In the latter city all vocational instruction to factory workers is given in class rooms set aside in shops which are called extensions of the public schools.

PUBLIC SCHOOLS CAN ASSIST BY VARIOUS METHODS

It is an excellent arrangement when space in public school buildings or an extension of the public schools in a local plant can be provided for the instruction of apprentices. Industries thru taxation help to support the public schools and are justly entitled to this assistance which most school officials are glad to furnish to local industries when they know how to go about it.

It may be of interest to know that while several states spend hundreds of thousands of dollars of local, state and federal school funds in giving related instruction to apprentices, several other states in which foundries have recently reported no such educational opportunities for their employes, in one year turned back into the federal treasury nearly $150,000. of the public funds which have been and are each year appropriated for this purpose of improving workers in industry.

The exact total returned for the school year closing 1924 is $144,936.40. This amount of federal funds allotted to states for the training of industrial workers was turned back to the federal treasury by 31 of the 48 states, while 17 states including those having well established apprenticeship programs used their entire share of the federal funds and much larger sums of state and local school funds. In a few cases privately managed schools are giving valuable assistance in education for the industries. All such local possibilities should be investigated by the management.

Although it is economical and advisable from several standpoints for one or at best all the plants in a community to cooperate with schools in the offering of related instruction to apprentices, fortunately there are two other courses open when cooperation with the schools is not practicable at the present time.

COOPERATION BETWEEN PLANTS IS BENEFICIAL TO ALL

(2) When a number of plants cooperate in an apprenticeship program without the assistance of the public schools, these cooperating plants may provide a centrally located class room, engage capable instructors and arrange courses of instruction. Centrally located class rooms may be rented or one of the plants may offer the use of a room. This does not incur any great expense. Simple class room furniture is provided. Furniture consisting of chairs, and a table or tables to serve as desks, a blackboard and such other equipment as may be needed.

This arrangement has many advantages, since the apprentice may go directly from work to the class room without great loss of time and the class room atmosphere does not entirely lose the influence of the plant spirit.

A second advantage of this arrangement frequently is that evening classes for journeymen are held in this room directly after working hours. Larger attendance and greater interest is usually said to be the result.

CLASS ROOMS IN PLANTS HAVE MANY ADVANTAGES

A third advantage of class rooms provided by plants may result from the employment and training of plant executives as teachers. This is discussed later under the subject of instructors.

Perhaps the greatest advantage of beginning related instruction in a small way when there are no other facilities available is that the experience thus gained and the interest of students and teachers can be carried over into a larger program when

cooperation is arranged between all local plants and the public schools.

If a number of plants in one locality do not yet see the value of a general training program and the assistance of the schools cannot be secured, the one manager who does have this understanding may carry on a training program independently until such time as others are ready to join.

PLANT CLASS ROOMS SHOULD NOT BE OVER EQUIPPED

(3) When a plant provides its own class room, a small room may be arranged for this purpose. This has been done successfully by a number of plants and involves very little expense. The equipment is such as was suggested for the class room provided by several plants. As in the case of a number of plants providing space for the instruction of apprentices in related subjects, all the experience and interest developed will make just that much easier the sound growth of a training program with the establishment of co-operation with other plants and public schools.

Whether an individual plant is conducting related instruction with no cooperation from any source or all the plants in a district are cooperating with the public schools or there is any other kind of a plan part way in between these extremes, the selection of instructors and of instructional material presents a few similar problems which should be considered as soon as the place of giving related instruction has been decided upon.

14 - Related instruction - instructors.

When the public schools are carrying a portion of the responsibility for the education of apprentices by offering instruction in related subjects, the school officials usually are quite willing to confer with interested plant officials regarding the selection of instructors and the planning of the instruction. When this is done and when the teachers are of the type approximating in general characteristics high grade industrial executives, the results are satisfactory.

WHERE POSSIBLE INSTRUCTORS SHOULD BE CONNECTED WITH INDUSTRY

If related instruction is conducted in a plant or in a school privately managed by several companies the instructors may be selected from among plant executives or employes who possess the information to be presented. In many cases draftsmen and engineers are found who are capable and also willing to give instruction. Since instruction is usually given during only four hours a week and the number of foundry apprentices will not be great such related instruction will not add greatly to the duties of persons who are assigned to this activity.

One benefit which may be derived from having plant engineers or draftsmen give related instruction is that their instructional material will usually be confined to that directly related to shop work and examples will be taken directly from the plant operations. Occasionally a public school which cannot offer class room facilities is willing to assist these plant instructors in any way possible and to pay their salaries for the time devoted to this

class room work.

15 - Related instruction - subjects taught.

ONLY THOSE SUBJECTS WHICH MAKE IT EASIER OR CHEAPER TO DO JOBS SHOULD BE TAUGHT

The instruction which a worker needs in order to operate intelligently, depends of course upon his preparation when he enters his apprenticeship. Related instruction should be confined to just those subjects and just those lessons in these subjects which will make the performance of shop operations easier or cheaper. All apprentices will benefit by the same instruction in certain trade subjects and economics while English sufficient for intelligent understanding may be needed by some and not by others.

Those who have had charge of the instruction of foundry apprentices are generally agreed that the following subjects should be taught:

(1) Blue print reading, shop sketching and drawing.

(2) Shop mathematics.

(3) Science related to shop operations - physics, chemistry, metallurgy and mechanics.

ECONOMICS SHOULD BE TAUGHT

(4) Economics including industrial history.

(5) Trade subjects - a consideration of materials, shop tools, equipment, safety practices and industrial relations which will help the apprentice to begin to understand his work - will interest him in gaining more understanding.

(6) English as needed.

Instruction is organized differently in various plants as is illustrated by the outlines of courses given below and by samples of text material given on pages 26,27,28,29,30,31,and 32. As more different companies develop the courses which in their own plants accomplish the aim of related instruction, these varied experiences will be helpful to other companies.

BLUE PRINT READING AND SHOP SKETCHING SHOULD BE TAUGHT INSTEAD OF MECHANICAL DRAWING

In practically all cases the reading of drawings and blue prints is found of more value than mechanical drawing. Some drawing is helpful such as sketching of simple parts or drawing them on cross section paper. The mathematics is correlated closely with shop problems and usually begins with fractions and may include some plane and solid geometry and the use of trigonometrical functions in solving problems involving the right triangle. The type of geometry which interests mature journeymen as well as apprentices is illustrated by one of the lessons given later on Pages 30 and 31 The elimination of instruction not used in the foundry is shown by the fact that students frequently progress from the use of common

fractions to the solution of problems in geometry in less than fifty hours of class room instruction.

The science taught to apprentices is drawn from all those subjects which help to give the apprentice a better understanding of the materials and tools with which he is working. The lesson on the effect of phosphorus upon cast iron, given on Pages 29 and 30 illustrates this point.

YOUNG WORKERS SHOULD BE TAUGHT THE FUNDAMENTALS OF INDUSTRIAL BUSINESS

The science, mathematics and drawing are frequently related to shop operations as is illustrated by the questions on the lessons on flasks and on clamps, weights and binders on Pages 27 and 28. The economics is intended to give apprentices an understanding of the organization of industrial life and the responsibilities of each factor in it. This subject is usually presented in short talks by shop executives and others.

Trade subjects are given in courses of various names but the purpose is always the same - to acquaint the apprentice with shop tools, equipment and materials and his own responsibility for safety.

A list of the subjects which are included in the various branches of foundry instruction is given on pages 18 and 19 of Training Bulletin No. 24 of the U. S. Department of Labor -

SUBJECTS SHOULD BE PRACTICAL. THEORY SHOULD BE CONFINED TO THE WHY OF THE JOBS.

1. Definition of foundry
2. Products of foundry
3. Foundry terms
4. Tools, equipment, care and use of same
5. Safety and sanitary conditions
6. Core practice
7. Care of patterns
8. Supplies and their use
9. Foundry sands
10. Molding practice
11. Shrinkage and contraction
12. Characteristics of metals
13. Cause of defective castings
14. Melting practice
15. Melting mixtures
16. Pouring practice
17. Cleaning of castings
18. Miscellaneous mixtures and their purpose
19. Foundry calculations
20. Ovens, their construction and operation
21. Weight and strength of materials used
22. Blue print reading
23. Inspection
24. Laboratory and its use to the foundry
25. Foundry construction
26. System and management

A Milwaukee foundry includes shop calculations, blue print reading and sketching, and metallurgy in related shop technique which is outlined as follows:

Related shop technique.

	40	hours shop calculations
	20	" reading drawing (Shop sketching)
	10	" general appliances and processes
	10	" green sand molding (4 parts)
	10	" core making
	10	" machine molding
METAL	10	" dry sand, loam work
MIXING	10	" foundry appliances (2 parts)
IS THE	16	" foundry chemistry (3 parts)
HEART OF	10	" cupola practice
FOUNDRY	30	" steel making
SCIENCE	10	" mixing cast-iron
	10	" malleable castings (3 parts)
	40	" steel castings (3 parts)
	40	" metallurgy
	20	" foundry materials (sand, etc.)
	30	" heat treatment
	10	" foundry layout and organization

The related trade technique courses in this foundry are summarized as follows:

Related trade technique courses.

Shop mathematics,.....	252 hours
Economics,.....	84 "
Chemistry, Physics and Mathematics,.....	84 "
Related shop technique,.....	—

In addition to these subjects of instruction the apprentices in this plant are given a series of special or shop talks. The subjests of these are given below:

SUBJECTS ARE LESS IMPORTANT THAN INSTRUCTORS SUBJECT MATTER AND METHODS OF INSTRUCTION

1. Shop etiquette
2. School etiquette
3. Working with the foreman
4. Working with the men
5. Working with fellow apprentices
6. Overhead
7. Manufacturing
8. Conducting a business
9. Big business
10. Your employer
11. The company's policies and traditions
12. The apprentice organization
13. Citizenship
14. The home maker
15. Taxes

(Continued on page 25)

16. Civic duties
17. The open shop
18. Production
19. Ambition
20. Promotion
21. Your trade as an asset
22. Apprenticeship as a character builder
23. Your parents and apprenticeship
24. Safety
25. Loyalty
26. Objective
27. Sanitation
28. Work and sports
29. Diplomacy

In a number of plants lectures or shop talks are illustrated by the stereoptican by which means boys learn the story of iron ore, new kinds of foundry equipment, safety methods and many other things.

16 - Related instruction - some questionable text material.

While industries may profit by the schools' assistance in teaching subjects related to industry, industrial managers should keep an active interest in the material taught. This is particularly necessary in such subjects as Vocational Guidance and Community Civics which are frequently taught to all students and in which there is an opportunity for developing attitudes for or against certain industries and industrial life.

SCHOOL BOOKS SHOULD BE EXAMINED

Industrial managers should know what is taught in these courses relating to industry. The following extracts are taken from a well advertised text book:

"Danger of Blind-Alley Work . . . . Most of the work which children do is blind-alley work. Do you know what a blind-alley is? It is one of those narrow streets or roads that suddenly ends in a high fence, and you cannot get out unless you go back the way you came. It does not take you anywhere, as a real street does."

"The Best Job for You . . . . No job that you can now find in any mill or factory can help you much to find the kind of work that you are best fitted to do, and no such job can get you ready for that better work. Such a job can only cause you to drift about for several precious years."

"Choosing a Career . . . . Young people who leave school at an early age to take work in factories or stores or in the blind-alley occupations of the streets, begin to drift about from one job to another, and frequently drift about for much of their lives."

"Occupations to Avoid . . . . Finally, there are the blind-alley jobs. These jobs lead nowhere, and waste the time that should be spent in preparation for real jobs in later life. The bootblack in a city is following a blind-alley occupation; so is the newsboy; and so is the telegraph messenger. Most factory work is blind-alley work, especially for boys, . . ."

Following this lesson during which the teacher has presumably impressed upon the children the truth of the statement that factory work is blind alley work the student is given a number of assignments as "Something to do and talk about". Among these assignments is the following:

"Make a list of blind-alley jobs in your community."

Since the student desires to please the teacher and get a good grade he will quite naturally list all the factories in his community. This school book is by no means an exception. Other material of even more misleading nature is being studied by students in our public schools.

It is only fair to remark that there is much good material in the book from which the above quotations were taken. In some respects this book is an excellent text book but these objectionable and wholly misleading statements become all the more dangerous when included in a text book which contains a mixture of truth and falsehood. Industrial leaders share with all other progressive persons a desire that children may be accurately informed regarding occupations but there can be no defence for a text book which asserts that boys who take employment in factories have no careers. School officials should pay more attention to the selection of text material and not leave this to a committee of teachers whose experience does not fit them to pass judgment upon such matters.

17 - Related instruction - kinds and examples of text material.

THREE ESSENTIALS OF SUBJECT MATERIAL

Whatever kind of instructional material is used, it should meet three requirements. Instructional material should be brief and confined to that subject matter which will be immediately helpful in the foundry industry. It must also be in such form that it will be of interest to the average apprentice who is trying to get ahead in the foundry. Lastly, instructional material should be in such form that it can be easily used by the apprentice and by the apprentice instructor, foreman or other person in charge of the work.

Descriptions of foundry processes and related questions were discussed on Pages 16, 17 and 18 under the subject of instructional material for shop training. These descriptions of foundry processes may be used directly as text material in related subjects or may be the source from which lessons in mathematics, drawing and other subjects are drawn.

QUESTIONS SHOULD STIMULATE THINKING

Questions relating to foundry practice are one good type of instructional material. These questions may be included in lessons of other kinds as previously described or they may be used as the basis for instruction by lecture, discussion and home use of references.

Lesson sheets on certain subjects in mathematics, science and drawing as applied to foundry operations are used in many places.

EXAMPLES of Lesson Sheets shown in Training Bulletin No. 24, Industrial Training for Foundry Workers, U. S. Department of Labor, Pages 26 and 27 are given below.

ALL INSTRUCTION MUST BE PLANNED TO MEET THE NEEDS OF EACH INDIVIDUAL

Addition of decimals
Foundry Work

RULE:-

To add decimals proceed as in addition of whole numbers, but keep the decimal points under each other.

Sample problem

Iron in charge	Amount used	Pounds silicon
Silver gray	100 lbs.	0.50
No.2 Northern	500 "	1.20
No.2 Southern	200 "	0.90
Scrap	200 "	0.55
	1000 lbs.	3.15

Iron in charge	Amount used	Pounds sulphur
Silver gray	100 lbs.	0.0024
No. 2 Northern	500 "	0.030
No. 2 Southern	200 "	0.030
Scrap	200 "	0.010
	1000 lbs.	0.0724

Notice position of decimal point.

Using the above amounts of iron to get a charge of 1000 pounds, we find that we will have 3.15 (read three point fifteen) pounds of silicon and .0724 (read point naught seven twenty four) of a pound of sulphur in the charge.

Blue print reading
Foundry work

(Blue print of bushing is given here.)

Scale 1" = 1'

Answer the following questions

BLUE PRINTS ARE GRAPHIC DIRECTIONS SHOWING HOW TO DO JOBS

1. What does scale 1" = 1' mean?
2. What do the dotted lines represent?
3. Are any lines or circles omitted?
4. Would there be a dry-sand core used in making this casting?
5. Would the core be made in two parts or as a solid core?
6. Would this casting be made by using a split pattern or a solid pattern?

7. Would there be any loose pieces on this pattern?
8. What would be the approximate weight of the casting?
9. Is the above projection correct?

EXAMPLES of questions which follow lessons describing equipment and operations.

Course A, Lesson #3, Apprentice Molders' & Coremakers' Course, Industrial Association of San Francisco:

Questions on bottom boards.

1. What is a bottom board?
2. What materials are bottom boards made of?
3. What kinds of bottom boards are used for snap and squeezer machine work?
4. What material for bottom board is suitable for medium size repetitive work?
5. What material is suitable for heavy work?
6. What is the danger of using warped or broken bottom boards?
7. What is smooth board?
8. How does a smooth board help a pattern?
9. Why should smooth boards have large cleats?

QUESTIONS SHOULD BE PRACTICAL

Questions on clamps, weights and binders

1. Why are clamps used?
2. What determines the number of clamps to use?
3. Does fast pouring put a strain on mold?
4. How does slow pouring reduce strain on mold?
5. How should clamps be put on a flask?
6. What is danger in clamping too hard?
7. Describe weighing down of mold.
8. Why should joints on flasks be wedged before placing on heavy weights?
9. What materials are weights for snap flasks made of?
10. How is the weight required to hold down cope figured?
11. Work out problems -
    a. Molding surface area 24" x 36".
    b. Depth of cope sprue 8".
    c. Size wood cope 30" x 42 x 8".
12. Describe bolting down of pit mold.

QUESTIONS WHICH DO NOT APPLY DIRECTLY TO THE PLANT SHOULD BE AVOIDED

EXAMPLES of lessons in metallurgy and solid geometry.

These lessons illustrate a type of instructional material of equal interest to apprentices and journeymen. They are taken from short courses in metallurgy and mathematics which together with shop sketching and blue print reading, all strictly related to foundry work, have been taught to evening classes composed of both apprentices and highly skilled journeymen. The lesson sheets were specially prepared for the classes so as to include immediate problems, students were supplied with copies and a considerable amount of home work including reference reading and solution of additional shop problems was done by the students. One lesson was usually covered in from one to three class periods depending entirely upon the class.

Lesson No. 8 - Phosphorus and its effect upon cast iron.

INTEREST CAN BE GREATLY STIMULATED BY SCIENTIFIC INFORMATION

1. Discovery - The element phosphorus was discovered by the alchemist, Brand, of Hamburg in 1669, while searching for the philosopher's stone which was expected to change base metals to gold. It was not until the demand for phosphorus in the manufacture of matches that it was produced on a large scale.

2. Occurrence - Because of the great chemical activity of phosphorus it never occurs free in nature. In the form of phosphates it is very abundant and widely distributed. Phosphate rock is deposited in various regions. Calcium phosphate is the chief mineral constituent of the bones of animals and is an important element in plant and animal growth.

3. Manufacture and use - Phosphorus is now manufactured from bone ash or from a pure mineral phosphate by heating with sand and carbon in an electric furnace. On account of the great affinity of phosphorus for oxygen, it is always preserved under water. Phosphorus is used largely in the manufacture of fertilizers sold under the name of superphosphate of lime.

4. Amount of phosphorus in pig iron and foundry iron.
In ordinary pig iron the range is from a trace to 1½%.
In foundry iron the usual range is from .25% to 1%.
In Bessemer iron the amount of phosphorus present is less than .10%.

5. Effect of phosphorus upon cast iron.
(a) .75% and over can cause "cold short".
(b) Increased hardness when present in amounts over 1.3%.
(c) With phosphorus between 0.20% and 0.04% with silicon 2.5% to 2.75% and sulphur about .05%, castings can be made which permit of being bent and punched.
(d) Over 1% it is the most weakening element.
(e) Should be kept down to not exceed .8%
(f) Use in counteracting the hardening effects of sulphur.
(g) Adds ductility to the iron.
(h) Adds fluidity.

6. The effect of adding phosphorus in the ladle.

(a) A flux or cleaner of the iron.
(b) Methods of adding.
(c) Hardening the iron.

Questions

ALWAYS TIE UP INSTRUCTION BY ASKING QUESTIONS ON THE LESSON

1. Which is the more important element from the molder's standpoint, phosphorus or sulphur? Give reasons for your answer.

2. In what class of castings is phosphorus used? What is the reason for its use?

3. Why should one never handle phosphorus sticks with bare hands?

4. Is phosphorus ever added to the cupola charge? If not where does the phosphorus in the iron come from?

5. Questions of students.

References

REFERENCES TO BOOKS ENCOURAGE READING

Metallurgy of cast iron, Chapter XXXl. T. D. West.

Foundry Work, Pages 122, 136, 170, 171.B. L. Gray.

Lesson No. 3 - Pyramids, cones and frustums.

Definitions

(Definitions and illustrations of (1) pyramid, (2) circular cone, (3) axis of a cone, (4) cone of revolution, (5) frustum, (6) altitude of pyramid, (7) altitude of cone, (8) altitude of frustum.)

Formula and rules

(Formulas and rules for finding the volume (1) of a pyramid or a cone and (2) of the frustum of a pyramid or cone.)

Examples

1. Find the weight of a cast iron tapered pin in the form of a frustum of a cone of revolution, having a lower base 8" in diameter and upper base 5" in diameter and a length of 24".

MUCH OF THE MATHEMATICS AND CHEMISTRY MAY BE APPLIED TO FOUNDRY WORK

Use formula (2) which is $V = (B + b + \sqrt{B \times b})\ 1/3\ h$

$B = 8^2 \times .7854 = 50.2656$ sq. in.

$b = 5^2 \times .7854 = 19.635$ sq. in.

$h = 24"$ 1/3 of 24 = 8"

$V = (50.2656 + 19.635 + \sqrt{50.27 \times 19.64}) \times 8$

$V = 101.33 \times 8$

$V = 810.64$ cu. in.

The weight is then $810.64 \times .26\# = 210.77\#$

2. Find the volume of the cone of revolution cut from the frustum described in Problem No. 1 if the original casting was a cone.

(a) The altitude of the part cut off is found by proportion. The difference in diameter of the bases is 3" and the altitude is 24", then $3:5 = 24:h$. $h = 40$ the altitude of the cone cut off.

The volume is found from formula (1) which is $V = 1/3\ Ah$

$A = 5^2 \times .7854 = 19.635$

$h = 40$

$V = 1/3 \times 19.635 \times 40$

$V = 261.8$ cu. in.

Related problems.

1. Find the weight in brass of a cone of revolution whose altitude is 8" and whose radius of base is 4.887 in.

2. What would be the altitude of the frustum of the cone of Problem No. 1, if the frustum and cone cut off had equal weights?

3. A ladle is in the form of a frustum of a cone. The diameter of the base is 40", the diameter of the rim is 58", the depth is 28". How much iron will the ladle hold if filled to within 4" of the rim?

4. Calculate the weight of a casting in the form of a pyramid whose base is an equilateral triangle 15" on a side and the altitude of the pyramid 20".

Note: These foundry problems in solid geometry and other more complicated ones brought by the students were mastered by one class in about 55 hours of class room instruction after the students had begun the study of decimal fractions as applied to foundry operations. This same apparently rapid rate of progress was later made by other classes in which instruction was carefully limited to that which applied to shop operations.

18 - Related instruction - Method of furnishing text material.

That method of furnishing text material is best which provides the most useful material at the least expense.

INSTRUCTORS SHOULD TEACH APPRENTICES RATHER THAN SUBJECTS

One good method is to select instructors who know the subjects they are to teach and who are interested in their students and then train these instructors to prepare brief text material suited to their classes for use in connection with printed reference material. These lessons can be typed or mimeographed at small expense.

Correspondence courses have been found most satisfactory by some companies. The foundry may furnish the material or students may be asked to purchase courses or the expense may be divided.

Combinations of correspondence courses, reference material and specially prepared lessons are sometimes made.

Easily accessible reference material should always be furnished but the instructor must take the responsibility of encouraging and guiding the students' use of this material. A list of references on foundry work compiled from those recommended by many companies and instructors in shop or related subjects of value in foundry training and education is contained in Appendix II of this publication.

19 - What becomes of apprentice graduates?

The question of the future of apprentice graduates naturally concerns both those managers who are investing in a system of apprenticeship and those others who are seeking to make their present programs of larger service.

The answers to the questionnaires sent out to company members in March, 1925 by the Education Department of the National Founders Association gave some encouraging information and also indicated the need for future study.

A number of companies are able to retain 75%, 80%, even practically 100% of their apprentice graduates within their own plants. Several factories, some large and others small, report that they have very few men in their plants who were trained elsewhere.

One factory, to which reference was made on page 7 of "Employe Training" published by this Department, with a production force of 4200 men has gone outside its organization once in 10 years for a foreman. Of the last 17 foremen engaged, 15 were former apprentices in this plant.

The National Industrial Conference Board in Service Letter No. 262, March 3, 1925 gives the following facts from the experience of a manufacturing establishment which has conducted an apprentice school for 20 years and has kept records of the positions held by its apprentice graduates. While these are not foundry apprentices the example indicates what does occur in some metal trades and is possible in foundries.

During this time 808 men completed the course and at the time the record was compiled about one-half were still in the employ of the company which had trained them. Only 12 were known to have definitely left the trade for which they had been trained. Of the number remaining with this company, approximately 400, the majority were engaged in the trade for which they had been trained, although a considerable number had advanced to such positions as foremen or salesmen. Of the total 808, 234 had advanced to positions of higher grade than journeymen. Naturally some of these had left the company, even becoming proprietors of their own establishments while others had become superintendents or executive officers of corporations.

These reports coupled with others of quite different nature regarding the difficulty of retaining graduates suggest the advisability of a careful study of a number of questions among which the following may well be included---What care can be taken in the selection of apprentices which will insure desirable apprentice graduates being kept in the industry? Under the conditions existing in various places, what is the proportion of apprentice graduates which should be expected to remain in the plant? What can be done to retain this desirable percentage?

20 - Plan of publications.

The aim of this publication has been to give a brief resume of practices and methods now in use in certain foundries. It will be understood that this study is not at all complete. A complete study would require many months and would include many times the amount of material assembled here. This publication, including its appendixes on text material and references, is considered as an emergency announcement of present average practices and methods. It may serve as a tentative guide to those who feel the need for immediate organization of some kind of foundry training.

Other publications of this Association dealing with the same subject are as follows:

A - Foundry apprenticeship
B - Employe training

(Copies of these may be obtained upon request.)

The next study to be published in this series will deal with the practices and methods followed in schools offering foundry training and instruction.

The Association hopes to be able to announce in the near future a publication dealing with the question of Industrial Relations and Foreman Training.

In the meantime this department is issuing a number of articles dealing with general personnel activities which have previously appeared in magazines or have been the subjects of addresses. Some of these are as follows:

C - The human factor in industry
D - Returning to first principles

(Continued on page 34)

E - The fundamentals of industrial relations
F - Developing a safe human factor
G - What should we see in our jobs?
(This (G) is prepared in answer to a demand for an article in simple language. About 90% of the words are of one syllable. Employers should interest themselves in having this article used by teachers of English for foreigners, Elementary Civics and Vocational Guidance.)

H - The super-power of friendship - How a cooperative spirit may be developed in factories.

Copies of these may be obtained upon request by company members. Other requests will be met as far as possible.

21 - Questions for discussion.

The following questions are adapted from Training Bulletin No. 24, Industrial Training for Foundry Workers, U. S. Training Service, U. S. Department of Labor. Foundrymen may find it of interest to copy certain questions for presentation to workmen or may find them useful when interrogating prospective workers.

Cleaning room

1. Name methods of cleaning castings in the gray iron foundry.
2. Why do castings have to be cleaned?
3. Should they be cleaned in a department separate from the molding department?
4. What is the effect of shipping improperly cleaned castings?
5. Name some of the tools employed in cleaning castings.
6. Is it an advantage to the boy who is learning the foundry trade to be employed in the cleaning room of the foundry for a definite length of time?
7. What can the boy learn about molding in the cleaning room of a foundry?
8. In what way are good castings made into bad castings in the cleaning room?
9. Is there ever any way of repairing a casting that is found to be bad in the cleaning room?
10. Should the foreman of a cleaning room understand molding and core making? If so, why?
11. What is first done to the castings in the cleaning room?
12. Is there any skilled help in the cleaning room?
13. What is meant by "pickling" castings?
14. What acids are used in the pickling process?
15. What acid is more commonly used, and why?

16. What is oil of vitriol?
17. What is its chemical symbol?
18. Explain just how the cleaning is accomplished when oil of vitriol is used in the pickling process.
19. When mixing the solution what precaution must be used. Tell why.
20. In the case of burns resulting from the pickling solution, what should be done immediately?
21. The tank that contains the oil of vitriol solution should be of what material, and why?
22. Explain how the castings must be arranged when they are to be pickled.
23. How long a time are the castings generally exposed to the pickling solution?
24. What is the usual mixture when using oil of vitriol?
25. Does a stronger solution do the work more quickly or better?
26. What is done to the castings after being exposed to the pickling solution?
27. What should be done in order to entirely remove all traces of the acid?
28. Why should all traces of the acid be removed?
29. What are the advantages of cleaning castings by the pickling solution?
30. Is there a disadvantage in this method?
31. What other acid is sometimes used in the pickling solution than oil of vitriol?
32. In what way does this acid differ from the oil of vitriol in its action on the castings to be cleaned?
33. What special precautions must be taken in using and handling this acid?
34. Name an advantage that this acid has the oil of vitriol has not.
35. Why is not this acid more generally used?
36. In the foundry what is meant by tumbling barrel?
37. Why do we put small star-shaped castings in a tumbling barrel?
38. Why do we sometimes put pieces of wood in the tumbling barrel?
39. Of what advantage is this method of cleaning castings?
40. What is the injurious feature of this method of cleaning castings and how is this injurious feature overcome?
41. In what way do we use the sand-blast in the foundry?
42. Explain the apparatus and the method of cleaning castings by the sand-blast process?
43. What is the advantage of this method?
44. Why is it not more generally used?
45. Describe the helmet the operator should wear and why he should wear it?
46. Why must the sand-blasting of castings be done in a department separate from the molding department?

Core making

1. What is a core?

2. Of what materials is a core made in a foundry making grey iron castings?
3. What kinds of sands are used in cores?
4. Name various core binders.
5. Explain about the various core binders, telling advantages and disadvantages of each?
6. Explain two methods of coring holes through a casting at a level below the joint line?
7. How may a warped core plate be used for baking a flat core?
8. How are irregular shaped cores like port cores baked?
9. Why must a coremaker know how the core that he is making sets in the mold?
10. Why must the coremaker use an open-grain sand for his cores and why must he be particularly careful about his vents?
11. Why must binders be thoroughly mixed with the sand when making core mixtures?
12. What is the effect on the castings of too much binder in the core mixture?
13. What is the effect on the casting of too little binder in the core and mixture?
14. What is the difference between a dry-sand core and a green-sand core?
15. In what way are cinders used in the core sand?
16. What should be the approximate temperature in degrees Fahrenheit of the core oven?
17. What is the effect on the casting if the cores are not properly baked?
18. What is the effect on the core and on the casting if the temperature of the oven is too high?
19. Why are some cores made and baked as half cores, then pasted?
20. Explain operations necessary to finish a core ready to be set in the mold when it was made and baked in halves.
21. How do you sometimes take off the vent from an intricate shaped core (i.e., a port core)?
22. When making cores, in what way do we strengthen them?
23. How are cores secured or supported in a mold?
24. What methods require the greater skill, making cores in green sand or making cores in dry sand?
25. Have green sand cores an advantage over dry sand cores? If so, state advantages.
26. In what way is hay rope sometimes used in core room?
27. Explain operations necessary in sweeping up a pipe core.
28. Do we ever face cores? If so, why?
29. What are stock cores?
30. Explain construction and operation of a core-making machine for making stock cores.
31. Are there any other type of machines used for making cores?
32. Name three essentials in a core in order that the casting may be a good one and the core material easily removed from it.
33. What are chaplets?
34. Name and describe two types of chaplets.
35. Name and explain two ways that a chaplet might weaken a casting.
36. Why are chaplets generally given a coating of tin?
37. State advantages of linseed oil in cores as a binder.

38. How is molasses used in the core room?
39. In the core room, what are crabs, and how are they made?
40. Why can we use the core sand mixture for making only one core?
41. In making a small cylindrical core why should we not use a rod almost the diameter of the required core?

Apprentice molder on floor.

1. In the pattern shop, what is the definition of "shrinkage?"
2. In the foundry, what is the definition of "shrinkage?"
3. In the foundry, what is the definition of "contraction?"
4. What is the reason that a casting sometimes cracks while cooling?
5. What can be done to prevent a casting from cracking while cooling?
6. Explain why too much moisture in the mold will result in a bad casting.
7. What is the effect on a casting when the cope "pulls down?"
8. Explain the "pulling down" of the cope of a mold.
9. Explain what can be done to prevent the "pulling down" of a cope.
10. Why is it necessary to have a soft bed when casting flat plates without a cope?
11. What is the effect of cooling a casting by exposing it to the air?
12. What is a shrink head?
13. What is a churning head?
14. Why do we sometimes use a pressure head?
15. What do we mean by "bedding in" in the foundry?
16. What do we mean by "rolling over" in the foundry?
17. State reasons why we sometimes make a mold by the "bedding in" method.
18. Do dry sand molds require as much skill in molding as green sand molds?
19. Are dry sand molds rammed as hard as green sand molds? Why?
20. Are dry sand molds vented as much as green sand molds? Why?
21. Why can we get a better casting by the dry sand method than we can by the green sand method?
22. When we have a lathe bed casting to make that is 35 feet long, why do we not have a complete pattern?
23. When we have a lathe bed casting 35 feet long to make from a pattern 6 feet long, explain how to make cope to cover the molds.
24. Explain how we sometimes can make good a bad casting by burning on.
25. What precaution must be used when we are attempting to save a casting by burning on?

Bench work

1. Explain advantages of the tight or box flask cover over the snap flask.
2. Explain advantages of the snap flask over the tight or box flask.

3. When is it necessary to use a false cope?
4. Why is it necessary to vent sand molds?
5. Explain method of making a plaster of paris match plate.
6. Explain method of making a three-part job in a two-part flask.
7. Why is the sand used for bench work generally finer than the sand used for floor work?
8. Explain why the bench molder generally uses a different kind of parting material than the floor molder.
9. In connection with bench molding, explain what is meant by the term "stamping back."
10. Explain the difference in use of a moldboard and a bottom board.

Assistant to floor molder

1. What is foundry work?
2. What is a flask?
3. Name and describe all parts of a flask.
4. Name and describe types of flasks.
5. State advantages of each type.
6. Name material used in making flasks and state the advantage of these flasks.
7. What is a pattern?
8. In the foundry, what is meant by draft?
9. What classes of sand are used in the foundry?
10. What classes of castings are used in making machinery and what determines which class shall be used?
11. Name branches of iron castings.
12. In the foundry, what is meant by the following: Sprue pin, gate, riser, vent?
13. Name the grades of molding sands.
14. What grades of molding sands are used in making molds for brass or bronze castings?
15. What grades of molding sand should be used in making molds for plate castings of brass?
16. Where does molding sand come from?
17. Name elements in molding sand.
18. What are the properties of a good molding sand?
19. State what elements give to the molding sand these properties.
20. Name harmful elements in molding sand and state why they are harmful.
21. Name branches of molding.
22. Explain method of making a green sand casting.
23. Explain method of making a dry sand casting.
24. Explain method of making a loam casting.
25. Explain method of making a skin-dried casting.
26. Explain method of making an open sand casting.
27. State one advantage of each of the above methods of making castings.
28. In the foundry, what is the definition of molding sand?
29. Explain the requirements of a molding sand.
30. In molding sands, why are rounded grains preferred to angular grains?

31. Why should the grains be uniform in size?
32. What is the objection to driving wedges under clamps on a flask containing a completed mold?
33. What does a cubic inch of cast iron weigh?
34. What effect on the casting will result from too much ramming of the sand in the flask?
35. A foreman said to a molder, "Have you taken precautions to avoid shrinkage in that casting?" What did he mean by "shrinkage" and what precautions could be taken?
36. Name three essentials in a mold in order to get from it a good casting.
37. Name three good qualities a casting should have.
38. Name three defects that might occur in a casting and explain the reasons for them.
39. Name three forms of gases which must be allowed to escape from a mold when it is poured.
40. Name three things that are used to secure a mold when making it.
41. Describe several methods of securing a mold after it is made and before pouring in the metal.
42. Why does a mold have to be secured after it is made and before pouring in the metal?
43. What is fire clay?
44. Explain how it is used in the foundry.
45. What are follow boards, or match plates?
46. Of what materials are they made?
47. Of what advantage is a match plate?
48. Name, describe, and tell how the tools supplied to the molder by the foundry are used.
49. Name, describe and explain the use of the tools in the average molder's kit.

Journeyman molder.

1. In what way does the facing material for dry sand work differ from the facing material for green sand work?
2. How does loam sand differ from molding sand?
3. If you were going to use the loam method explain the rigging necessary to make a cylindrical casting 24 inches inside diameter, 48 inches long, 1 inch in thickness, with a 2-inch flange top and bottom and a 2-inch face.
4. Why do castings made by the dry sand method of molding generally have larger fins on them than if made by the green sand method?
5. Do castings made by the skin-dried method also have large fins? Give your reason for your answer.
6. When making a loam mold what do we mean by "headers?"
7. Explain operations necessary to secure a loam mold after it is closed and before pouring in the metal.
8. What do we use as parting sand in loam molds?
9. Why is it that sometimes the only method of molding that can be used to get a casting is the loam method?
10. Why do we sometimes have to make a mold other than straight in order to get from it a straight casting?

11. Explain method of drawing off the vent from a casting made in the floor of the foundry.
12. How do we draw off the vent from the checkered part of the mold?
13. In making a large lathe bed casting should the riser be left open or closed? Explain your answer.
14. Why is it sometimes necessary to allow the metal to cool before pouring into the mold?
15. Why do the lower sections of deep molds have to be rammed harder than the upper sections?

Assistant to melter

1. Name two types of furnaces for melting in the gray iron foundry.
2. State the advantages of each of these types of furnaces.
3. Is the metal charged into the two types of furnaces in the same way? Explain your answer.
4. Is a wind belt on a cupola furnace a necessity?
5. What are the tuyeres of a cupola furnace?
6. Are they a necessary part of the cupola furnace?
7. What regulates the height of the tuyeres in a cupola furnace?
8. Make a sketch of the air furnace showing principal features in the type.
9. What do we mean by the melting zone of the cupola furnace?
10. Where is the melting zone situated and what determines its situation?
11. What is meant by the sand bottom of the cupola furnace?
12. What is the tapping hole of a cupola furnace and explain how it is formed?
13. What is the effect of placing too little fuel between charges in the cupola furnace?
14. Explain some of the requirements when selecting a sand to use for the sand bottom of the cupola furnace.
15. Explain the putting in of the sand bottom of a cupola furnace, stating the precautions in ramming and shaping.
16. What is considered a good melting ratio of iron to fuel in a cupola fuel?
17. What is the theoretical melting ratio of iron to fuel in a cupola furnace?
18. What is the effect of placing too much fuel between charges of iron in a cupola furnace?
19. What is a flux?
20. What is the object of using fluxes and of what advantage are they?
21. Name some of the fluxes commonly used in a cupola furnace?
22. Why should a new cupola lining be dried before running off a heat in the furnace?
23. Why is it that it takes more pounds of fuel to melt a given number of pounds of iron in a short heat than it does in a long heat?
24. If you are required to melt two or more grades of iron in the same heat in a cupola furnace how can you prevent them from mixing?
25. In starting a fire in a cupola furnace why should we use a minimum amount of shavings and wood?
26. Describe the cleaning and repairing of a cupola furnace, stating what precautions should be taken with the work.

27. If the furnace has been out of blast for a long time what extra precautions must be taken when repairing the lining and why?

28. Name materials used in a typical daubing mixture.

29. Give a mixture that could be used for a breast mixture and mixture that could be used as a body mixture.

30. Make a study of the cupola furnace and then give a list of names of the various parts, stating the function of each part.

31. Is a double row of tuyeres an advantage in a cupola furnace?

32. How long a time will the cupola furnace melt iron before it is necessary to dump and clean it?

33. What are the materials of which firebricks are made?

34. Mention other materials sometimes used in the manufacture of firebricks.

35. Name some of the reasons for the destruction of the firebricks of the cupola furnace.

36. Explain the charging of the cupola furnace.

37. Should the fuel and iron be charged together, or separately, and should care be used to keep the charges level? Explain your answer.

38. Should the charges in a cupola furnace be packed closely? If so, why?

39. What is the result on the melted metal if larger pieces of scrap are charged than should be charged?

40. Should the cupola furnace be kept full of charges until all metal is charged? Explain your answer.

41. What is the blast?

42. Why is it necessary in melting iron in a cupola furnace?

43. About how many cubic feet of air are necessary to melt a ton of iron?

44. Does the speed at which the air enters the furnace have much effect on the speed of the melting?

45. What is meant by perfect combustion?

46. What is the result of too much pressure in a cupola furnace?

47. Name various reasons for using coke as a fuel in a cupola furnace.

48. Name reasons why coal might be used as a fuel in a cupola furnace.

49. Can oil or gas be used as a fuel in a cupola furnace?

50. Name some reasons why the iron melted in a cupola furnace might be too dull to run the castings.

51. What do we mean by the slag hole of a cupola furnace?

52. Where is it generally situated and what determines its height?

53. Name and explain the two types of blowers commonly used to provide blast for the cupola furnace.

54. Why should everything put into the cupola furnace when running a heat be accurately weighed?

55. Why should the cupola charging sheets be checked up in the office?

Mixing foundry facings

1. In the foundry, what is the definition of the material "facings?"

2. Explain how facing sand is prepared.

3. What is the object of using facings?

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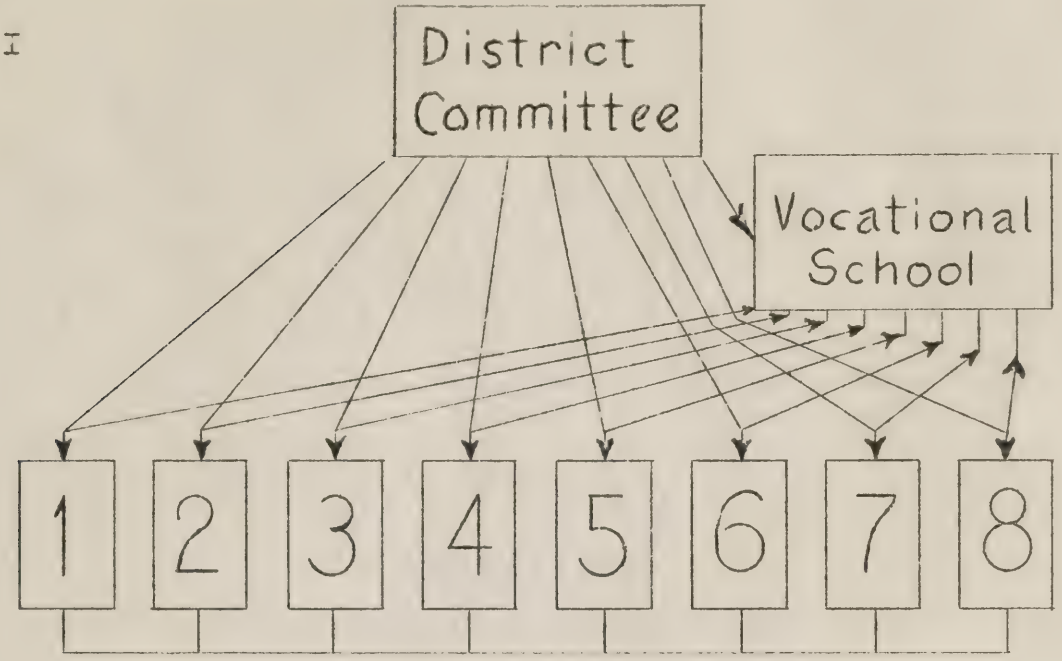
4. How is this object accomplished?
5. Name the quality that all facings must possess and state why this quality must be present.
6. Name and describe the principal facings used in the foundry.
7. Tell where the principal facings are found.
8. Tell how the principal facings are manufactured.
9. What determines the per cents of the sea coal to be used with the sand when mixing facings?
10. Why must the facing mixing be thoroughly done?
11. What effect do the facing materials have on the molding sands?
12. When we get the proper molding sand will facing be necessary?

Cooperative District Plan
Including Public Vocational School

Page 43

Chart I



District Committee of factory representatives and a representative of the vocational schools.

Individual Plants 1, 2, 3, 4, 5, 6, 7, 8. in which shop training and some plant courses are given.

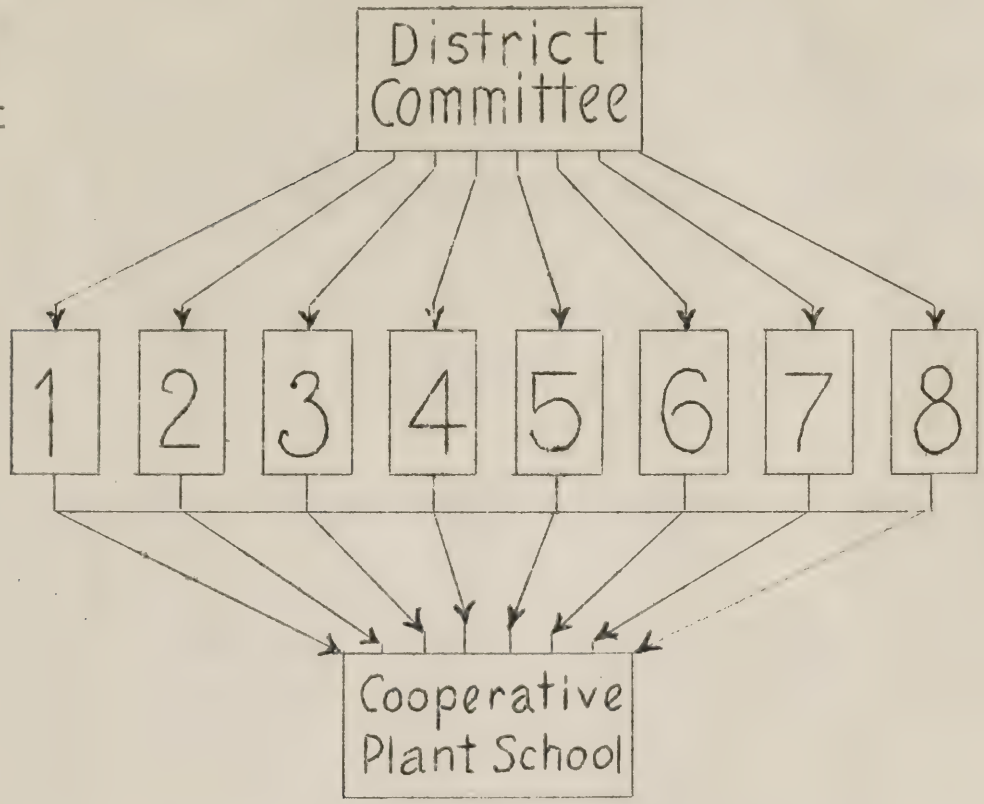
Vocational School - 3 possible types of instruction:
(1) Part time for apprentices and others.
(2) All day trade. (3) Evening.

Cooperative District Plan

With privately managed school.

Page 44

Chart II



District Committee of factory representatives and a representative of the vocational schools.

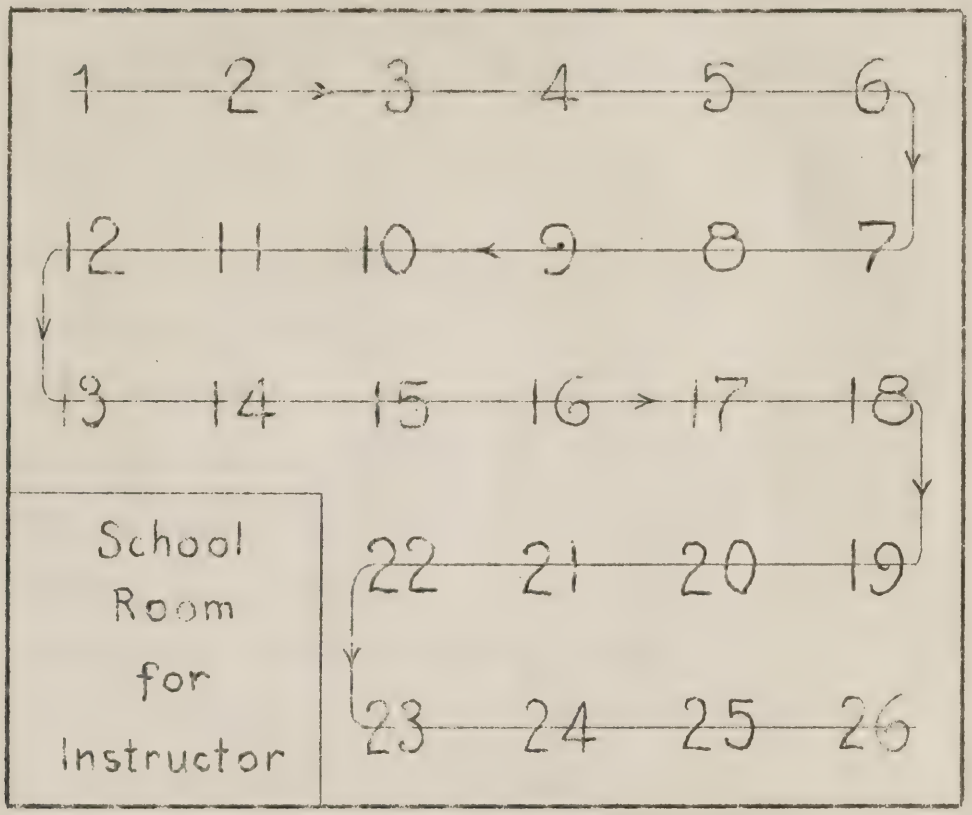
Individual Plants 1, 2, 3, 4, 5, 6, 7, 8. in which shop training and some plant courses are given.

Cooperative Plant School in which related mathematics, science, drawing and foremanship methods are taught.

Individual Plant Plan for Employe Training

Page 45

Chart III



Jobs in the plant 1 to 26 graded according to learning difficulties and probable line of advancement.

School Room - Simply equipped and set apart for instruction.

Instructor - with sufficient time and authority to carry out program.

APPENDIX I

MAKING DRY SAND CORES.

By W. C. Wright - National Founders Association

	Page
1. Jobs in the core room,.....	1
2. Definition of core,.....	1
3. Kinds of cores,.....	1
4. Materials used in making dry sand cores,.	2
5. Preparation of core sand,.....	3
6. Getting tools together,.....	3
7. Ramming core boxes for small cores,.....	3
8. Baking of cores,.....	4
9. Cooling and storing of cores,.....	5
10. Making larger cores,.....	5
11. Methods and devices of saving labor in the core room,.....	6
12. Questions,.....	7
13. References,.....	7

APPENDIX I

MAKING DRY SAND CORES
By W. C. Wright - National Founders Association

Note — This description of a foundry process has been prepared for two purposes: first, to serve as an example of the brief text material which can profitably be more generally prepared than it is at present by foremen and training departments in plants and associations and second, as the first of a series of descriptions of foundry processes which this Association is undertaking to prepare upon the request of its membership. It is emphasized that this material is merely an introduction for the new worker and a basis for further study.

Many foundries start an apprentice in the core room for a number of reasons. An apprentice may remain at this work for several months. In some foundries approximately three months are given to the core room. In others it would hurry a boy to learn all the core room jobs in six months.

1 - Jobs in the core room.

The core room jobs to which workers are assigned are about as follows:

1. Preparation of core sand - cutting over and riddling.
2. Getting tools together.
3. Making small cores.
4. Baking of cores.
5. Cooling and storing of cores.
6. Making large cores - rodding, venting and pasting.
7. In addition each worker should learn as much as possible of equipment and methods for saving labor in the core room.

2 - Definition of core.

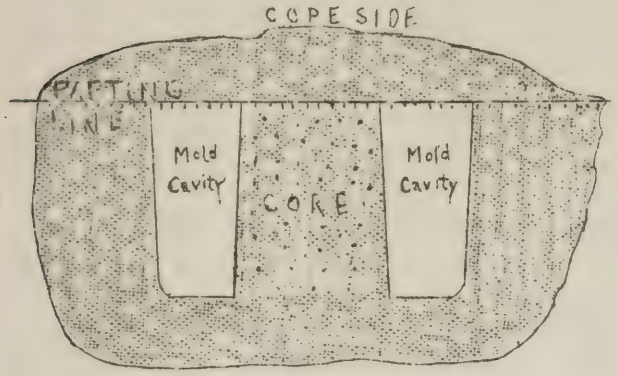
If we make a solid cube of cast iron, we shall not need a core, but if we make a pipe, a core will be necessary in order to form the hole; so a core is a body of sand or other material that forms inside part of the castings or forms holes in the casting.

3 - Kinds of cores.

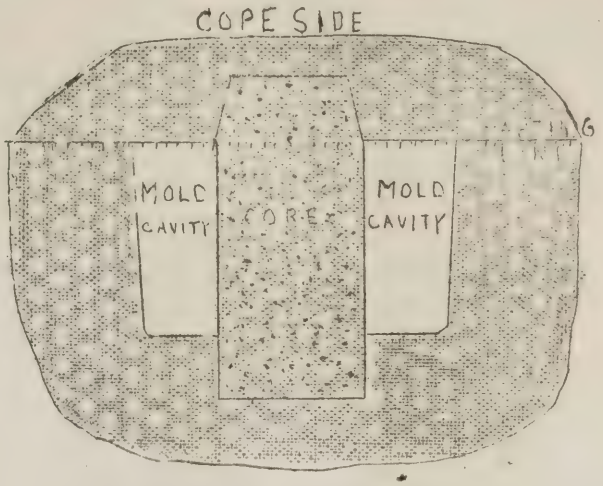
Cores may be made of dry sand, green sand, loam or, more rarely, of other materials.

A dry sand core is one that is baked in an oven and this baking makes it hard. Dry sand cores are the kind most used. We shall study the making of dry sand cores at this time. A green sand core is made of molding sand and is used without baking or is left in the mold when the pattern is drawn. When the pattern is drawn the

mass of molding sand of which the green sand core is made makes a hole in the casting. Loam cores are made from loam mixtures and are used in loam molding. They are used generally in making large castings.



GREEN SAND CORE



DRY SAND CORE

4 - Materials used in making dry sand cores.

The principal materials used in making dry sand cores are sand, binders of various kinds, blacking, wire, rods and paste.

Core sand is generally sharp sand such as river sand, lake sand, sea sand or silica sand. It is sand that has little or no alumina or organic matter which is found in loam. Binder is the material used to hold the sand together when it is baked. The important binders are oil, flour, pitch and molasses. During mixing it spreads thruout the sand and thus coats each particle of sand with this material.

To summarize: The binders give strength to the core by (1) melting when they spread thru the core thus coating each particle of sand with binding material, (2) baked and dried the particles cling together, (3) when baked we have a firm body of sand which may be handled.

Blacking is some form of carbon ground fine and mixed with water. Common forms are black lead and ground charcoal. Blacking is used to coat dry sand cores and prevent the hot iron from penetrating the core. This gives a smooth, clean hole.

Wire is used to strengthen small cores and rods are used to give strength to the larger cores. Paste is flour and water mixed like heavy cream and is used to hold two parts of a core together. When dried in the oven the paste becomes very strong. Flour is sometimes used also as a binder.

5 - Preparation of core sand.

Core sand may be prepared for use either by hand or by machinery. When it is prepared by hand about 60 pails of lake sand are spread two or three inches thick over a clean floor. It is then ready to be mixed with the binder. The selection of the binder depends upon many factors, one of which is whether the cores are to be used immediately or to be stored. Oil is most commonly used when the core is to be stored. After spreading the sand one pail of oil is sprinkled over the sand after which the mixture must be cut over two or three times so that each particle of the sand may become coated with the oil. If the cutting over is not thoroughly done, weak spots will occur in the cores.

Each class of sand is different so no exact proportion of sand and binder can be given. The more binder used, the stronger the core will be. If a little new molding sand is added it gives strength to the core before baking. This will be necessary if any part of the core overhangs. The addition of a little flour to the mixture also adds greatly to the strength of the core both before and after baking. As soon as the flour becomes dampened by the moisture in the sand it forms a paste which helps to hold the particles firmly together. This paste is strengthened in the baking.

It is much more economical to mix the core sand in a mechanical mixer for the particles of sand are more thoroughly forced together and the oil or other binder becomes attached to every particle of sand. This makes less binder necessary and gives more even cores.

After the mixture has been cut over it is riddled thru either a hand riddle or better thru a power riddle. This mixing breaks up any lumps or balls of sand and gives a more thorough mix to the mass. A little water may be added to the mixture if it is too dry so the sand will pack readily together. The amount of gas in cores and the ways by which it can escape when the hot metal is poured are very important subjects which will be discussed later.

6 - Getting tools together.

The core bench should be provided with the following tools: a rammer, a vent wire, hard brush, rubber or rawhide hammer, some plates and a solid plate of iron which should be put on the bench. The rammer is used to pack the sand firmly into the box and can be either a small hard stick or iron that will easily enter the box. In larger work a hand rammer is used.

7 - Ramming core boxes for small cores.

The core box is made the exact shape and size of the core wanted and is generally split so as to be in two parts. It is made in two parts so it can be easily removed from around the core.. The parts of the box are doweled together and held firmly by a spring or screw-clamp while the core is being made. Where cores are small faster progress is made by having a multiple box - that is, a box that will produce several cores at once instead of one.

Place the core box on end on the iron plate and with one hand full of core sand, pour the sand into the box and with the rammer in the other hand pack the sand firmly into the box. When the box is rammed full strike off the top of the box smooth and push the vent wire thru each core.

The vent hole thru the core allows a rapid exit for the gases that will form when the core comes in contact with the molten iron for the binder and the organic matter in the sand will produce much gas when the core is nearly surrounded by molten metal. Since gas takes up about a thousand times more space than the matter from which it is produced a very small amount of matter will produce a large amount of gas. If no vent is provided thru the core this gas will seek an exit thru the molten metal or the molten metal will "boil" and blow around the core. This will cause a bad casting and is referred to as "core blowing".

The box is now placed on the core plate that holds the cores in the oven. This plate is usually a flat steel or cast iron plate, easy to handle when filled. The box is given two or three raps with the hammer so as to losen the core from the box, then the clamp is removed. The box is drawn a half at a time and the cores are left on the plate. When the plate is filled it is ready for the oven.

8 - Baking of cores.

The process of baking small and large cores is somewhat different but the same general principles apply in both cases.

Core ovens are generally heated by a coke fire underneath the floor; two flues should connect the oven to the stack. The flue at the top of the oven carries off the smoke of a new fire and is closed after the fire is well started. The other flue enters at the bottom of the oven near the floor. The heated air goes to the top of the oven and as it takes up the moisture of the wet cores it becomes heavy and falls to the floor where it should be drawn off by the lower flue.

The proper baking of cores is not only a problem of heat but equally a matter of circulating hot air to take up the moisture and carry it away. The cores should be thoroughly baked for if any moisture is left in them there is danger of a blow when the mold is poured.

In the baking of smaller cores either the ovens are supplied with racks to hold the plates or an oven of the drawer type is used. About two, to two and one-half hours are required to bake small cores in which oil has been used as the binder. When baked these cores have a dark brown color.

The larger cores are placed on a car which is sometimes supplied with racks to hold the plates. When filled, the car is pushed into the oven on rails made for this purpose. Large cores are usually baked during the night. In the baking of both large

and small cores some thought should be given as to where to place the core in the oven for proper baking. The higher in the oven the hotter it is and this intense heat will burn very small frail cores which bake fine lower down. Cores having greater bodies of sand require more heat so should be placed nearer the top. If the core is burned the binder becomes ruined and the core crumbles readily. The hot metal frequently cuts a burned core.

9 - Cooling and storing of cores.

When baked and cooled off, the cores are either conveyed directly to the molder using them or packed in wooden boxes and placed in the storage racks. If cores are to be stored for any length of time, the binder used is important for some binders will allow the core to absorb moisture. Such binders as flour, resin and molasses allow the cores to gradually absorb moisture from the air and so in time they become soft, while the oil binders keep the core hard and dry for long periods. If the core has absorbed moisture it should again go thru the oven before being used. A damp core will surely result in a bad casting.

10 - Making larger cores.

The making of large cores offers greater difficulties than does the production of small cores. The principal difficulty is in tying the core together with rods so that it can be rolled over when necessary, handled with the crane or hung in the cope if required. The rods used should be bent to fit the shape of the core as nearly as possible and the rods should lead to the hooks which are inserted to handle the core, so that when the core is lifted by the crane the weight will be distributed on the rods. This will overcome the danger of the core breaking or the lifting hooks pulling out. The lifting hooks are kept below the face of the core and the sand is dug out so they can be reached to hook into. Then after the core is set in the mold these hooks are covered by ramming some core sand into the cavity and drying the spot by using a torch or placing a hot plate over it until thoroughly dried.

Next to properly rodding a large core, comes the proper venting of it to provide certain and rapid exit for the gases that will form when the mold is poured. Large cores are vented in various ways. Where the core is sufficiently large to allow it, a quantity of small pieces of coke is rammed up in the core center and a track of this coke leads to the outside portion that forms the print. If a vent wire is used freely to make holes from the coke bed to every portion of the core, the gas will collect in the coke bed and pass off thru the opening to the print. It is better to overdo the venting, rather than to fail to vent some portion for over venting does no harm but not venting enough will almost surely produce a bad casting.

Thin, frail or very crooked small and medium sized cores are

often vented by the use of wax or paraffin cord. This can be purchased ready for use and can be rammed up into the most intricate or thin section. When the core is baked this wax or paraffin melts and leaves a hole plenty large enough to allow a free vent.

Where the core is made in two parts, each part should have a good deep channel cut thru the different parts and leading to the print. When the parts are pasted, a piece of rope can be put into the channel and later pulled out, thus insuring a free opening.

Small cores, where oil is used as binder, are seldom coated with blacking. Coating cores with blacking will be described in a later paper.

11 - Methods and devices of saving labor in the core room.

The use of the multiple box in making small cores has already been mentioned as have several other labor saving machines.

When the same large cores are produced frequently, much time can be saved by making a cast iron arbor to strengthen the core instead of using so many rods. The arbor can be in several parts when the parts are bolted together and should be made to carry the weight of every part of the core. The arbor should have lifting hooks cast into it so placed that when the core is lifted by the hooks the core will balance or nearly so. By ramming the arbor as close to the bottom of the core as possible, the weight will be carried by the arbor and few, or no rods are required. This arbor is easily made and is a great labor saver.

There are some machines used in the core room that make the process faster on some classes of cores. This is true of round cores of many sizes. This class of core is called a stock core. When made by machine, they are absolutely round, are evenly rammed and are made about 18 inches long and then cut to the required length as used.

In making cores on this machine, the temper or dampness of the sand is important. If the sand is too wet the cores are rammed too hard as the damp mixture does not leave the machine fast enough. By using oil binder and keeping the mixture rather dry the core comes from the machine readily, producing a core of correct density and strength. The cores are run out of the machine on to corrugated plates for easy baking and handling. They are made up in stock of such sizes as are frequently used and piled and stored ready for use by simply cutting to length and filing the ends to fit the print if a tapered print is used. Small jarring machines are labor savers in ramming medium sized cores. The box is placed on the machine, filled partly full of sand, then any rods necessary are placed in position, the box filled heaping full of sand and the machine rams the whole body firmly together. The top is then butted and struck off and the plate clamped on.

In many specialty foundries or those equipped to produce one line of work, notably the automobile foundries, much use is made of the roll-over, straight drawn type of machine to produce the water-

jacket cores for cylinders. In this case the corebox is firmly fixed to the platen of the machine and after the core is rammed up and struck off, the core plate is put on and the plate and core rolled over, the clamp released and the core lowered by the machine free of the box. Due to the perfect draw of the machine, the core needs little or no patching and little skill is required to perform all the operations.

Questions.

1. What are the advantages of beginning foundry work in the core room?
2. What are the important characteristics of core sands?
3. What conditions may necessitate the addition of water in cutting over the sand? Explain.
4. Explain how you determine what binder to use in making cores.
5. Why must cores be dry when used?
6. Why vent cores?
7. What will happen if the core is not thoroughly dry when used?
8. Name two ways to save labor in the core room.

References.

Foundry Work, Pages 2, 6, 46, 48, 50, 51, 62, etc. B. L. Gray, American Technical Society, Chicago, 1920

Foundry Practice, Chapter 4, Pages 123-150. Tate & Stone, H. W. Wilson Company, Minneapolis, 1906.

NATIONAL FOUNDERS ASSOCIATION
29 South LaSalle Street, Chicago

APPENDIX II

REFERENCE MATERIAL
By L. A. Hartley, Director of Education

	Page
1. For apprentices and molders,.....	1
2. For use in pre-foremanship training,...	3
3. Economics and Civics,.....	7
4. Science, Physics, Mathematics, Chemistry, Drawing,.....	9
5. English,.....	10
6. Health and sanitation,.....	11
7. Inspirational,.....	11
8. English for foreigners,.....	12

Reference material

Note: The following books and publications have been mentioned by foundrymen as being useful in training apprentices or others who may be engaged in foundry work. As in the cases of various other details of training it is in order to observe that reference material which would be ideal in one situation would not be at all adaptable in another. For example, apprentices are found who are unable to read or write in any language and who cannot solve simple problems in addition and subtraction. On the other hand, apprentices are found who have finished with excellent credit the first two years of college training before entering upon their apprenticeship. In each case the apprenticeship program was regularly organized in a systematic manner. The reference material is presented under eight classifications as follows:

1 - Reference material for use of apprentices and molders.

Title	Author	Publisher
Foundry practice	Palmer	Wiley
Foundry practice	Tate & Stone	Wiley
Foundry work	Wendt	McGraw-Hill
Foundry work	Gray	American Technical Society
Foundry work	Stimson	American School of Correspondence
Elementary foundry practice	Richards	Macmillan
American foundry practice	West	Wiley
The steel foundry	Hall	McGraw-Hill
The molder's text book	West	Wiley
Text books on foundry practice	International Correspondence School	International Text Book Co.
Text books on foundry practice	American Correspondence School	American Correspondence School
General foundry practice	McWilliams & Longmuir	Lippincott
Production of malleable castings	Moldenke	Penton
Brass and iron founders' guide	Larkin	Baird

Title	Author	Publisher
Open hearth steel casting	Carr	Penton
Converter steel casting	Simonson	Penton
The cupola furnace	Kirk	Baird
Foundry iron	Kirk	Baird
Cast irons	Keep	Wiley
Malleable cast iron	Parsons	VanNostrand
Modern founder Practice	Sharp	Spon
The Encyclopedia of founding	Bolland	Wiley
Foundry nomenclature	Buchanan	Spon
Core making	Moldenke	Corn Products Refining Company
The foundry	Mortiel	Penton
Machine molding	Lewis	Tabor Manufacturing Company
Pattern making & foundry practice	Hand	Drake
Notes on foundry practice	Morgan	Lippincott
The practical iron founder	Horner	VanNostrand
General foundry practice	Roxburgh	VanNostrand
Cast iron	Hatfield	Lippincott
American pattern shop practice	McCaslin	East Technical Hich School, Cleveland, Ohio
The stripping plate machine	Committee on Foundry Methods	National Founders Ass'n
The roll-over straight draft molding machine	Committee on Foundry Methods	National Founders Ass'n
Power squeezers	Committee on Foundry Methods	National Founders Ass'n
Hand squeezers with pattern and flask equipment	Committee on Foundry Methods	National Founders Ass'n

Title	Author	Publisher
Benefits to be derived from the use of molding machines	Committee on Foundry Methods	National Founders Ass'n
Service bureau suggestions for the installation of molding machines	Committee on Foundry Methods	National Founders Ass'n
Transactions of the American Foundrymen's Association. Vol. XXXI	Various authors on many interesting foundry subjects	American Foundrymen's Association
Manual of instruction for welding operators	Welding Engineer	Welding Engineer
2 - Reference material for use in pre-foremanship training.		
14th U. S. Census Table 6, page 384	U. S. Census	U. S. Bureau of Printing
The human side of production	J. M. Larkin	National Founders Ass'n
Apprentice education Bulletin 87	Federal Board for Vocational Education	U. S. Bureau of Printing
Eighth annual report	Federal Board for Vocational Education	U. S. Bureau of Printing
Increasing man power through management	L. W. Olson	Industrial Management
Inadequacy of foundry training in Philadelphia	Alfred H.Williams Professor of Industry, University of Pennsylvania	The Metal Manufacturers' Ass'n of Philadelphia
Industrial training for foundry workers Bulletin No. 24	U. S. Department of Labor	U. S. Bureau of Printing
Foundry apprenticeship in Milwaukee	Committee on Industrial Education	National Founders Ass'n
Wastes in the metal trades industry, Waste in industry	American Engineering Council	McGraw-Hill
Report of the committee on industrial education	Committee on Industrial Education	National Founders Ass'n

Title	Author	Publisher
Employe training	Hartley	Chamber of Commerce of the United States
The human factor in industry	Hartley	National Founders Ass'n
Vestibule and upgrading schools of industry from a manufacturer's viewpoint. Bulletin No. 32	E. A. Barnes	National Society for Vocational Education
Manpower in industry, page 8, The Problems of training, and chapters 7, 20 and 21	E. S. Cowdrick	Holt
Returning to first principles	Hartley	National Founders Ass'n
The super-power of friendship	Hartley	Pennsylvania Manufacturers' Journal
Milwaukee continuation schools	Wisconsin State Board for Vocational Education	Wisconsin State Department of Education
Personnel work. Is it practical? Does it pay?	Dr. Harry Myers	National Founders Ass'n
Better foundry practice	Metropolitan Life Insurance Co.	Metropolitan Life Insurance Co.
As a man thinketh	James Allen	Regan Publishing Corporation
Foundry cost accounting-practice and procedure	Belt	American Malleable Castings Association, Cleveland, Ohio
How we think	Dewey	Heath
Human nature and conduct	Dewey	Holt
Vocational and moral guidance	Davis	Ginn & Co'
American democracy	Forman	Century Co.
Advanced American history	Forman	Century Co.
The mastery of speech	Frederick Houk Law	Independent Corporation

Title	Author	Publisher
My country	Turkington	Ginn & Co.
The American government	Haskin	Little & Ives Co.
Handling men	A.W.Shaw Co.	A.W.Shaw Co.
The knack of managing Analyzing the job-Planning	A.W.Shaw Co. Herbert Watson	The System Publishing Co.
Mind and work The psychological factors in industry and commerce	Chas. S.Myers	G.P.Putnam's Sons
How to study and what to study	Sandwick	Heath
The foreman and his job	Chas. R. Allen	Lippincott
The metal industries in Cleveland	Mary Price	The Consumers' League of Ohio
Part-time cooperative courses Bulletin No. 78	Federal Board for Vocational Education	U.S. Bureau of Printing
Evening industrial schools Bulletin No. 18	Federal Board for Vocational Education	U. S. Bureau of Printing
Foreman training courses Part 1. Bulletin No. 36	Federal Board for Vocational Education	U. S. Bureau of Printing
Foreman training courses Part 2. Bulletin No. 36	Federal Board for Vocational Education	U. S. Bureau of Printing
The foreman Bulletin No. 2 6	U.S. Department of Labor	U. S. Bureau of Printing
Employment management Its rise and scope Bulletin No. 50	Federal Board for Vocational Education	U. S. Bureau of Printing
The selection and placement of employes Bulletin No. 49	Federal Board for Vocational Education	U. S. Bureau of Printing
The wage setting process Bulletin No. 44	Federal Board for Vocational Education	U.S. Bureau of Printing
Industrial accidents and their prevention Bulletin No. 47	Federal Board for Vocational Education	U. S. Bureau of Printing

Title	Author	Publisher
The turnover of labor Bulletin No. 46	Federal Board for Vocational Education	U. S. Bureau of Printing
Technical education and the metal trades industries	National Industrial Conference Board	National Industrial Conference Board
The task of American industry and the National Industrial Conference Board	National Industrial Conference Board	National Industrial Conference Board
Bibliography of employment management Bulletin No. 51	Federal Board for Vocational Education	U. S. Bureau of Printing
How the foreman can promote shop efficiency	C. L. Alden	Railway Age Gazette. July 1, 1910
The art of handling men	James H.Collins	Henry Altemus Co.
A comparative study of wage and bonus systems	Harrington Emerson	The Emerson Co.
Foremen and accident prevention	Travelers' Insurance Co.	Travelers' Insurance Co.
Industrial leadership	Gantt	Yale University Press
Lessons in personal efficiency	Grimshaw	Macmillan
Shop management and systems	Jones	Industrial Press
Hiring the worker	R. W. Kelly	The Engineering Magazine Co.
Choosing employes by mental and physical tests	W.F.Kemble	Engineering Magazine 1917
Investigating an industry	William Kent	Wiley
Maximum production in machine shop and foundry	C.E.Knoppel	Engineering Magazine 1911
The personal relation in industry	John D.Rockefeller, Jr.	Library of Congress
Industrial fatigue	Russell Sage Foundation	Russell Sage Foundation Library 1917
Scientific Management	Taylor	Harper Bros.

Title	Author	Publisher
The art of handling men	E. Shinn	World's Work November 1905
The premium bonus system	W.R.Thompson	Doubleday-Page

3 - Economics and Civics.

Note: The reader of these references is reminded of the wide variation in the preparation of candidates for foremanship. This variation necessitates the listing of references covering a considerable range of understanding.

We and our work	J.F.Johnson	American Viewpoint Society New York
Living and working together	Morgan	Scribners
Industrial ownership	Brookings	Macmillan
Adult working class education in Great Britain and the United States Bulletin No. 271	C. P. Sweeney U. S. Department of Labor	U.S. Bureau of Printing
Standards of eighth grade attainment in shop work	W. T. Bawden U.S. Department of Interior	U. S. Bureau of Printing
Community score card	Federal Council of Citizenship Training. U.S.Department of Interior	U. S. Bureau of Printing
Economic civics	Hughes	Allyn & Bacon
Cost control for foundries	Everett & Heywood	McGraw-Hill
Present day immigration January 1921	Various authors	The Annals of The American Academy of Political and Social Science
Prices May, 1920	Various authors	The Annals of The American Academy of Political and Social Science

Title	Author	Publisher
The international trade situation, March 1921	Various authors	The Annals of The American Academy of Political and Social Science
Science in modern industry	Various authors	The Annals of The American Academy of Political and Social Science
Four years of labor mobility	The Industrial Research Department	Wharton School of Finance
Fifteen lessons in thrift	Savings Division U.S. Treasury Department	U. S. Bureau of Printing
Story of trade schools of the Industrial Association of San Francisco	The Industrial Association of San Francisco	The Industrial Association of San Francisco
Fuel economy	Engineering Experiment Station	University of Illinois
Cost finding Brass, bronze and aluminum foundries	Committee on Foundry Methods	National Founders Ass'n
Cost finding Grey iron foundries	Committee on Foundry Methods	National Founders Ass'n
The value of foundry cost keeping	Committee on Foundry Methods	National Founders Ass'n
Job specifications Bulletin No. 45	Federal Board for Vocational Education	U. S. Bureau of Printing
The foreman as a stock keeper	LaSalle Extension University	LaSalle Extension University
Makes machine tool castings	Pat Dwyer	The Foundry December 15, 1924
Commerce and industry	J. R. Smith	Holt
Principles of economics Revised edition, Vol. I	Taussig	Macmillan
Principles of economics Revised edition, Vol. II	Taussig	Macmillan

4 - Science--Physics, Mathematics, Chemistry, Drawing

Note: Again wide range of academic preparation is considered.

Title	Author	Publisher
Common science	Washburne	World Book Co.
Civic science in the home	Hunter and Whitman	American Book Co.
Creative chemistry	Slosson	The Century Book Co.
Vocational chemistry Note: Suggested only for treatment of soils and sand.	Willaman	Lippincott
Organic chemistry Note: Suggested for discussion of organic matter in sand.	Leffman and LaWall	Blakiston Co.
Plane geometry	Durell and Arnold	Merrill Co.
Applied science for metal workers	W. H. Dooley	The Ronald Press
Chemistry in the service of the state	University of Wisconsin	Department of Chemistry University of Wisconsin
General science	Elhuff	Heath
First year course in general science	Pease	Merrill Co.
Science of home and community	Trafton	Macmillan
Applied science for wood workers Note: Treats also of metals	Dooley	The Ronald Press
Metallurgy	Rhead	Longmans, Green and Co.
Qualitative analysis	Baily and Cady	Blakiston Co.
Inorganic chemistry	Newell	Heath
Practical physics	Carhart and Chute	Allyn & Bacon
Modern applied arithmetic	Neely and Killius	Blakiston Co.
Industrial arithmetic	White and Colgrove	Webb Publishing Co., St. Paul

Title	Author	Publisher
Hamilton's essentials of arithmetic. Books I, 2, and 3	S. Hamilton	American Book Co.
Fundamentals of practical mathematics	Wentworth, Smith and Harper	Ginn & Co.
Vocational mathematics	W.H. Dooley	Heath
Practical mathematics	C. I. Palmer	McGraw-Hill
Practical applied mathematics	J.W.L. Hale	McGraw-Hill
Shop arithmetic	Smith and Norris	McGraw-Hill
Mathematics for the practical engineer	Bromley and Cobleigh	McGraw-Hill
Empirical formulas	T.R.Running	Wiley
Slide rule simplified	Richardson	See dealers in Richardson's slide rules.
Practical drawing	H. W. Temple	Heath
Mechanical drawing	Linus Faunce	Hinds, Hayden & Eldredge Co.
Notes on mechanical drawing and drafting room practice	H.W.Anderson	Department of Engineering Ex. Iowa State College
Blue print reading	Givens	Wiley

5 - References treating of English which may be useful to foundrymen of varied preparation.

Elementary lessons in every-day English	Bolenius	American Book Co.
What is English?	Ward	Scott,Foresman and Co.
Knowing and using words	Lewis and Holmes	Allyn & Bacon
Vocational English	Bowlin and Marsh	Scott,Foresman and Co.

Title	Author	Publisher
English by practice Books 1, 2, 3, 4	Griffin and Moraff	Hinds, Hayden and Co.
A project book in business English	Cook	Holt
Working composition	Opdycke	Heath
12,000 words often mispronounced	W.H.P.Phyfe	Putnam Company
Reading with a purpose	W.N.C.Carlton	American Library Association
6 - References treating of health and sanitation which may be of interest to foundrymen of varied preparation.		
Principles of health control	Walters	Heath
The people's health	W. M. Coleman	Macmillan
Popular essays on the care of the teeth and mouth	V. C. Bell	Little, Ives and Co.
Healthy living, Book 2	Winslow	Merrill Co.
Primer of sanitation 1920 revision	Ritchie	World Book Co.
Town and city	F. G. Jewett	Ginn & Co.
Health, strength and power	Sargent	H.M.Caldwell Co.
Industrial hygiene and medicine	E. W. Hope	William Wood and Co.
Emergencies	C. V. Gulick	Ginn and Co.
Human physiology 1920 revision	Ritchie	World Book Co.
The body at work	F. G. Jewett	Ginn and Co.
Good health	F. G. Jewett	Ginn and Co.
Hygiene by experiment Book two	F. M. Gregg	The World Book Company
7 - References treating of subjects of an inspirational nature which may be of interest to young men engaged in foundry work.		
Every man a king	Marden	Crowell

Title	Author	Publisher
Men of achievement	Noah Brooks	Scribners
Self investment	Marden	Crowell
The exceptional employe	Marden	Crowell
Pushing to the front	Marden	Crowell
Men of business	Stoddard	Scribners
What should we see in our jobs?	Hartley	National Founders Ass'n
Stories of the day's work	Davis and Getchell	Ginn & Co.
Adventures in friendship	Grayson	Doubleday-Page

8 - References treating of English for foreigners.

Students text book	Raymond F.Crist U.S.Department of Labor	U. S. Bureau of Printing
English for foreigners Books 1 and 2	Sara R.O'Brien	Houghton,Mifflin Co.